Systems-Based Sustainability Analysis of Building 170, Fort McPherson, Georgia

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By:

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Abstract

This report, prepared for the Army Environmental Policy Institute (AEPI), describes the demonstration of a process for systems-based sustainability analysis to support the sustainable design and development of built facilities at Army installations. This process has been explored in the context of Building 170, an historical building formerly used as a medical clinic and being rehabilitated as office space to house AEPI and other tenants at Fort McPherson, Atlanta, GA. This building was part of earlier studies to develop sustainable design recommendations using the prevailing green building rating system in the U.S.: Leadership in Energy and Environmental Design (LEED). The present study had four objectives:

- To determine if any improvements can be made to the recommendations prepared by the working groups of the charrette for retrofit of Building 170
- To identify existing best available technologies and strategies that could be implemented to improve the sustainability performance of the proposed retrofit
- To delineate areas where research and development is needed to provide new technologies and strategies to improve sustainability performance
- To compare the outcomes of LEED-based solution development with systems-based solution development

The method used in this study was developed as a way to systematically identify the impacts of built facilities that influence its sustainability, in three categories: Stakeholder Satisfaction, Resource Base Impacts, and Ecosystem Impacts. Using the method of systems-based sustainability analysis, gaps were identified between three different possible configurations of the facility: the status quo state, the proposed retrofit state developed in prior studies, and the ideal sustainability state. The analysis revealed that the proposed retrofit state, developed as part of a charrette to develop sustainable design recommendations for the facility, had room to improve in terms of delivering a truly sustainable facility. The study identified over 150 recommendations of existing Best Available Technologies and Strategies (BATS) in four areas: Construction Inputs, Construction Outputs, Operations & Maintenance Inputs, and Operations & Maintenance Outputs. Additional areas for development of new BATS were identified, and performance-based specifications were used to articulate the necessary attributes of these new BATS.

The study found that while using LEED as a basis for developing design recommendations helps to identify the majority of BATS that apply to commercial buildings, there is still a gap between the resulting design and a truly sustainable design for a project. The systems-based sustainability analysis provides a method for systematically identifying these gaps and identifying not only what areas can be improved with presently-available technologies and strategies, but also what areas need new technologies and strategies that do not yet exist.

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Executive Summary

Introduction

The Army is interested in the concept of sustainable design and development in response to a variety of drivers, including Executive Order mandates, the importance of environmental stewardship in achieving the its mission, a desire to demonstrate environmental excellence, and a desire to save money while not compromising the mission of its facilities. Having set sustainability as a goal for its installations and their facilities, one of the significant questions the Army has is, "What makes a facility sustainable?" In the context of this study, a "sustainable facility" is one for which the current and probable future states of the facility cause no net negative impacts to resource bases or ecosystems (the two means by which humanity now and in the future will meet its needs), while satisfying the needs of its stakeholders, i.e., meeting mission requirements.

To further the goal of Army sustainability, this study considered the challenge of creating a built environment to meet two specific stakeholder needs of today's Army: (1) providing a facility to effectively house the operations and activities of the Army Environmental Policy Institute; and (2) putting an abandoned, historically significant building at Fort McPherson back into beneficial use. Together, these needs represent the core requirements that must be met by the project design and delivery of Building 170. In order for the Building 170 project to be sustainable, it must meet these two needs while not negatively impacting, either now or in the future, the resource bases and natural ecosystems on which present and future humans rely to meet their own needs. The purpose of this study is to demonstrate a systematic method for doing so, in the context of developing a design solution for Building 170 at Fort McPherson. The primary audiences of this report are: (1) the stakeholders and decision makers of the Building 170 project; (2) personnel responsible for making capital facility decisions for other Army facilities; (3) Army and Federal policy makers; and (4) the research and development community. The report describes the demonstration of a process for systems-based sustainability analysis to support the planning and design of a capital project to systematically identify technologies and strategies that will make the project more sustainable.

Given its interest in sustainable facilities as part of work in sustainable military installations, AEPI feels that restoring the building using sustainable facility technologies and strategies would accomplish the following goals relevant to its mission: (1) create a role model for future Army building projects; (2) demonstrate the core values of AEPI; and (3) develop alternatives to existing practices for historically significant structures that can retain their value without excessive cost. Prior to the study described in this report, AEPI commissioned three other studies to analyze Building 170 and identify opportunities for sustainability improvement: an initial case study analysis of the state of the building including limited improvement recommendations; a sustainable design workshop/charrette that brought together over 20 experts on various aspects of facility sustainability to develop detailed improvement recommendations; and a deconstruction analysis of the building that identified likely solid waste streams from the building renovation and potential destinations for those streams. The outcome of these studies was a set of design recommendations for the facility that could be used to retrofit the building to a gold rating level using the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system. This rating system uses a point-based checklist approach to set environmental performance requirements for buildings based on best practices. A gold rating is the second-highest possible rating under the LEED point system.

The outcome of these prior studies, while providing useful design recommendations, did not include two requirements that would aid AEPI in achieving its objectives for Building 170: (1) identifying how sustainable Building 170 will be as a result of implementing the recommendations in prior studies; and (2) documenting a generalizable process for identifying sustainability improvement options that will achieve sustainability goals for other building projects. The study described in this report was commissioned by AEPI to execute these tasks. The objectives of this project were four-fold: (1) to determine if any improvements can be made to the design recommendations from prior studies; (2) to identify existing best available technologies and strategies that could be implemented to improve the sustainability performance of the proposed retrofit; (3) to delineate areas where research and development is needed to provide new technologies and strategies to improve sustainability performance; and (4) to compare the outcomes of the LEED-based process with the systems-based sustainability assessment process used in this study. In meeting these objectives, the outcomes of this project were two-fold: (1) a set of recommendations related to Building 170 identifying ways in which the sustainability of the proposed retrofit can be improved through existing and yet-to-be-developed technologies and strategies; and (2) demonstration of the process of systems-based sustainability analysis as the foundation for the design and development of sustainable

Army facilities. The remainder of this Executive Summary describes the method used to achieve these outcomes, the results of the project itself, and the recommendations and conclusions generated by the study.

Method

To achieve the goals of this project, a systems-based sustainability assessment method was used to model the relative sustainability of three different facility states: (1) a baseline or status quo state of the building, defined as how the building would be renovated using typical practices without considering sustainability; (2) the proposed retrofit state defined by recommendations in previous studies, corresponding to a LEED Gold rated building; and (3) the ideal sustainability state of the building, defined as the how the building would behave if all sustainability objectives and constraints were exactly met. To identify improvements to the proposed retrofit state, the ideal sustainability state was defined from a performance standpoint, and this served as a starting point for a gap analysis comparing the proposed retrofit and status quo states to the ideal state. The ideal sustainability state was defined in terms of three basic constraints: (1) requirements for stakeholder satisfaction were exactly met; (2) no negative impacts to resource bases were caused by the project; and (3) no negative impacts to natural ecosystems were caused by the project. Then the other two facility states (status quo and proposed retrofit) were evaluated in terms of how well they performed in terms of these constraints. The resulting comparison showed that both the status quo and proposed retrofit states of the building had some unsustainable features. In other words, they had one or more of the following: (1) some unmet stakeholder requirements; (2) some negative resource base impacts; or (3) some negative ecosystem impacts. Therefore, neither of these comparison states were truly sustainable.

The overall assessment method used in this work is depicted in Figure 1. First, the three states to be compared were defined as listed earlier: the baseline/status quo state (to provide a benchmark for sustainability performance and establish a scope of analysis), the proposed retrofit state (defined by the recommendations of previous studies), and the ideal sustainability state (defined as how the building would behave if it were to exactly meet sustainability requirements). Specific information about the building and stakeholder attributes that affect the three sustainability factors (stakeholder satisfaction, resource base impact, and ecosystem impact) was collected and used to create a systems model/profile of each of the three states for purposes of comparison. The differences across the three profiles (determined from the systems models) were used to construct a gap analysis to indicate in what ways the proposed retrofit state was different from the ideal sustainability state. The outcome of the gap analysis was expressed in the form of sustainability improvement opportunities, which were used to search a pool of Best Available Technologies and Strategies (BATS) relating to sustainable facilities. BATS applicable to the opportunities presented by Building 170 (indicated on the left side of Figure1) were subjected to a feasibility analysis to determine if they met constraints identified by stakeholders. All BATS that met constraints were kept for further analysis, while infeasible BATS were discarded. Cost-benefit and risk assessments were made of the feasible BATS to prioritize remaining BATS into a set of recommendations for improving the sustainability of Building 170.

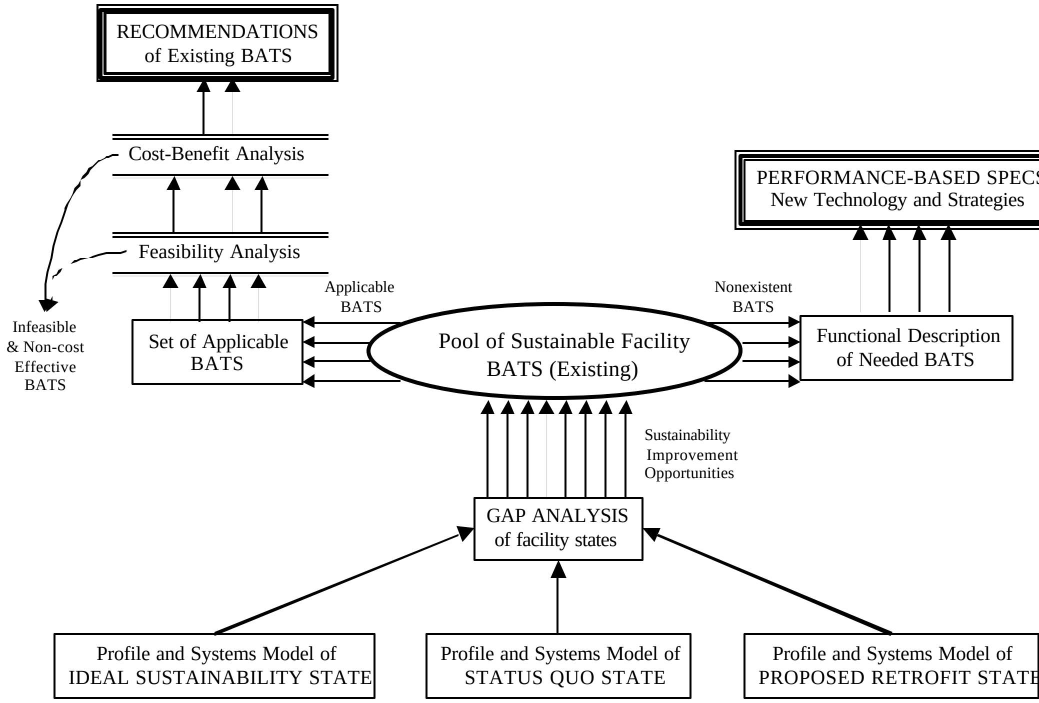

Figure 1: Overall Assessment Method

Some sustainability improvement opportunities were not able to be addressed by existing technologies and strategies. These opportunities represent needs for *new* technologies and strategies that should be developed to improve our ability to construct sustainable facilities in the future. These opportunities (indicated on the right side of Figure 1) were expressed in terms of performance-based specifications for the research and development of new sustainable facility technologies and strategies. This set of specifications comprises a research agenda for development of new technologies and strategies, one of the key objectives of this project.

The analytical method used to compare facility states in this project was systems modeling. The goal of systems modeling is to systematically identify the facility's impacts to resource bases and ecosystems for each system state, so that the system states can be compared in terms of how well they meet sustainability requirements. To identify impacts caused by the facility, potential flows of matter and energy both to and from the system were identified for each of the system states, along with sources or sinks for each of these flows. Impacts were determined by evaluating whether the net impacts of those sources or sinks were positive, neutral, or negative to resource bases and ecosystems. The impact of the system itself was then assigned as a share of the positive, neutral, or negative impacts caused by the sources and/or sinks. Each flow was considered individually, and the flows that caused negative impacts were identified as unsustainable features of the system. This set of flows with negative impacts comprised the gaps between the ideal sustainability state and the status quo/proposed retrofit states of the building.

To begin to identify specific ways to bridge the gaps, the next step was to identify what are the *drivers* of negative impacts that prevent the proposed retrofit state from meeting the requirements of the ideal sustainability state. This process is called Impact Chain Analysis, and works by tracing identified impacts of the facility system back to their root cause(s) within the system itself. The result of impact chain analysis is a complex web of connections linking user functional requirements with the building components that provide them and the affiliate systems that provide the matter and energy needed to construct and operate those building components. Impact chains were constructed for each of the major groups of unsustainable flows associated with Building 170 to pinpoint where interventions could be made that would reduce, eliminate, or offset any negative impacts of the proposed retrofit state.

Having identified specific opportunities to improve sustainability in the form of impact chains explaining the causes of negative impacts, the next step was to seek out ways to reduce, eliminate, or offset negative impacts associated with Building 170's proposed retrofit state. This process involved reviewing the knowledge base of existing Best Available Technologies and Strategies (BATS) for sustainable facilities to search for matches for each opportunity. For each opportunity, potential BATS were identified that might improve the sustainability performance of the resulting facility, i.e., reduce some negative impact caused by the facility as identified in the profiles. These potential improvement opportunities fall into four categories: (1) first-order strategies, involving actions taken *inside* the boundary of the system; (2) second-order strategies, involving changing the sources or sinks of flows to the system or the kinds of flows themselves; (3) third-order strategies, involving working directly with affiliate systems to help them improve their own sustainability; and (4) fourth-order strategies, where offsets are used to neutralize the negative impacts of the system by improving corresponding impacts in other, unrelated systems.

For each impact chain, the search for strategies started by seeking first-order strategies that would reduce the impacts of the chain to zero. If no BATS were found that were first-order strategies, then the search proceeded on through second-, third-, and fourth-order strategies until a solution was found that could reduce the impacts of the chain to zero. Then, the feasibility, costs, and benefits of all potential BATS applicable to Building 170 were assessed. For each BATS, a conceptual feasibility check was performed to determine if they could be applied without compromising stakeholder satisfaction requirements or other project constraints. Stakeholder satisfaction requirements identified for this project fell into four categories: (1) Environmental performance requirements; (2) Historic preservation requirements; (3) Building performance requirements; and (4) Project performance requirements. In parallel, BATS had to meet feasibility constraints in four categories: (1) Army regulations; (2) Historic preservation regulations; (3) Applicable building codes and standards; and (4) Project delivery constraints. BATS falling within feasibility constraints were considered in light of associated risk, reliability, value, and difficulty associated with the kind of strategy being used. Together, the four criteria return a qualitative comparison of the relative costs and benefits of each option. BATS were prioritized by sorting according to highest ratings in the four categories. Easiest difficulty BATS were ranked highest, followed by BATS with highest value, and BATS with highest reliability and risk.

After reviewing the pool of existing sustainable facility BATS, some sustainability improvement opportunities existed for which there were no BATS that could reduce negative resource base and ecosystem impacts to zero while maintaining stakeholder satisfaction. For these opportunities, functional descriptions were developed to describe performance requirements for new technologies and strategies that should be developed to fill these gaps. Together, these performance-based specifications comprised a research agenda for the development of new sustainable facilities technologies and strategies that can improve the sustainability of future Army facilities.

Results and Recommendations

The results of this project were four-fold, corresponding to the initial objectives of the project: (1) an assessment of whether improvements can be made to the design recommendations from prior studies to increase their sustainability; (2) an analysis of existing best available technologies and strategies that could be implemented to improve the sustainability performance of the proposed retrofit; (3) a research agenda delineating areas where research and development is needed to provide new technologies and strategies to improve sustainability performance; and (4) a comparison the outcomes of the LEED-based process with the systems-based sustainability assessment process used in this study.

The first result was an answer to the question of whether or not the proposed retrofit state from prior studies could be improved. The teams that developed the proposed retrofit state of Building 170 considered most of the major options for creating a sustainable facility within the scope of the study they chose. With few exceptions, their recommendations made use of Best Available Technologies and Strategies in the categories of impacts they considered in their study. However, the systems-based model identified two main types of impacts that keep the proposed retrofit state of Building 170 from being truly sustainable: (1) <u>Unavoidable impacts</u> of any facility project, such as the impacts associated with manufacturing products and transporting them to the project site, or the impacts associated with disposal of waste, even if that disposal involves recycling, and (2) <u>Unconsidered impacts</u> from categories that the team did not explicitly consider, such as most of the impacts associated with ongoing operations and maintenance of the facility. These unaddressed impacts represent opportunities to improve the sustainability of the proposed retrofit state. The recommendations generated in this study specifically address these impacts.

The second result of the study was an analysis of existing BATS that could be used to improve the proposed retrofit state, and a recommendation of specific BATS that could be incorporated in this project. Over 150 technologies and strategies were identified and prioritized that could be used to improve the sustainability of the proposed retrofit state, falling into four categories corresponding to the direction of flow and life cycle phase: Construction Inputs, Construction Outputs, Operations & Maintenance Inputs, and Operations & Maintenance Outputs. Recommended BATS ranged from “Avoid the use of heavy equipment during construction to avoid landscape disturbance”, to

"Require transport of all materials using sustainably-fueled vehicles or other sustainable mechanisms", to "Use LED lighting or CFL lighting that lasts longer and requires less frequent bulb replacement". A comprehensive listing of recommended BATS for this project is provided in Tables 3.1 – 3.4 of the full report.

The third outcome of this project was a research agenda to guide future research and development of sustainable facility technologies and strategies. Recommended research was organized according to seven different groups of negative impacts that could not be addressed using BATS for Building 170, due to: (1) <u>Import of new products</u> to the system, arising from the inevitable manufacture and transport impacts of those products; (2) <u>Export of waste</u> from the site, including transport, recovery, and storage impacts; (3) <u>Fugitive or unintended emissions</u>, such as waste heat or dust; (4) <u>Importing potable water</u> that originates outside the system; (5) <u>Large-scale wastewater treatment</u> using current best practices; (6) <u>Landscape disturbance</u>; and (7) <u>Electrical power generation</u> using current practices. Within each of these categories, performance requirements for future technologies and strategies were developed as a research agenda in terms of specific areas in which negative impacts need to be eliminated. In this study, the scope of analysis for generating R&D recommendations was limited to impacts identified in the context of this specific project. This set of recommendations is not necessarily comprehensive, since there may be additional needs in different contexts or for different types of buildings. Nonetheless, these impacts, identified in the systems-based analysis of Building 170, comprise the challenges that must be addressed to create a truly sustainable Building 170.

The fourth and final outcome of this project was a comparison the outcomes of the LEED-based process with the systems-based sustainability assessment process used in this study. While each approach has its strengths and weaknesses, one conclusion of this study is that it may be most effective to use the two methods in concert with one another rather than trying to optimize one or the other alone. The LEED-based method used in previous studies did a good job of identifying BATS that apply to this building situation, at least for the aspects of the facility it considered. In contrast, the systems-based sustainability assessment method is a more general method for identifying all the aspects of a built facility that need to be addressed in order to achieve sustainability. Used together, the methods can result in a more sustainable building than LEED alone. LEED plays the necessary function of quickly identifying the lowest hanging fruit for the project to which it is applied. Supplemented by the systems-based method to fill in the gaps, projects can result that approach the goal of true sustainability.

Discussion and Conclusions

The main findings of this project were associated with the ability of the systems-based assessment method to identify gaps in LEED-based sustainable design. The project found that, while LEED provides a straightforward and well-understood method for identifying sustainable best practices, it does not address all the possible impacts of a built facility that could affect sustainability. Therefore, projects that use LEED as a design tool will indeed be more sustainable than their traditional counterparts, but they may not achieve the goal of true sustainability. Accompanied with a tool such as the systems-based model that focuses on identifying and mitigating *all* impacts of the facility, the LEED tool can be very useful in creating more sustainable facilities. The systems-based analysis method was able to identify additional sustainability improvement recommendations not found using the LEED-based design method. These recommendations, if implemented in the Building 170 project, will result in a more sustainable building than could have been constructed based on prior work. For other Army facilities, the method demonstrated here could be applied to analyze proposed conceptual designs to search for improvement options, or as a basis for guiding the design process itself. The process is generalizable to other facility types, and the same steps can be applied to analyze many different kinds of facilities.

Additional findings of the project revealed that there are several kinds of unavoidable impacts of projects that may make achieving true sustainability virtually impossible using present methods. For example, there are impacts associated with the production and transportation of any kind of new product, and these must be completely eliminated or offset to achieve a truly sustainable facility. At this point in time, achieving true sustainability may be extremely arduous, although improvements to current practice can certainly be made. For stakeholders of the Building 170 project, the findings of this report indicate that there are additional measures (some of them very easy) that can and should be implemented as part of the project to make it more sustainable. For other Army facility decision makers and policy makers, this report should serve as an example of a potential tool in the arsenal of facility design and operations that can result in buildings better able to meet the needs of their stakeholders, with lower impacts over time and with ongoing benefits to the Army. Researchers and developers will also benefit from the research needs identified using the systems-based analysis method, since they will have a clear picture of what needs to be done to improve the state of the art in building technologies and strategies.

This study identified several areas for future research associated with systems-based sustainability modeling that should be addressed in future projects. First, quantitative models of system impacts should be developed in order to improve the ability of the model to compare alternatives. Second, while outside the scope of this study, using one type of impact to offset another (e.g., using water savings to compensate for energy consumption) may be useful to improve building sustainability, and may offer lower cost solutions for sustainability improvement. Merging the systems-based sustainability assessment tool with other tools for quantity take-offs, simulations, and design tools could significantly improve the time required to generate alternatives. Finally, a major challenge in this study involved finding ways to articulate stakeholder satisfaction requirements and constraints. Future research should address the need for fast, cost-effective, and accurate methods to elicit stakeholder preferences and requirements.

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1.0 Introduction

This report, prepared for the Army Environmental Policy Institute (AEPI), describes the demonstration of a process for systems-based sustainability analysis to support the sustainable design and development of built facilities at Army installations. This process has been explored in the context of Building 170, an historical building formerly used as a medical clinic and being rehabilitated as office space to house AEPI and other tenants at Fort McPherson, Atlanta, GA. The report describes the method of systems-based sustainability analysis and shows how it can be applied to the planning and design of a capital project to systematically identify technologies and strategies that will make the project more sustainable.

1.1 Sustainability and Army Capital Projects

The Army is interested in the concept of sustainable design and development in response to a variety of drivers, including[1]:

1) Executive Order mandates

2) Recognition of the importance of environmental stewardship in achieving the Army's mission

3) Desire to demonstrate environmental excellence in the development of a showcase facility that exemplifies the Army's environmental values

4) Awareness of a trend to reduce overall budgets for operating and maintaining military installations, without a commensurate reduction in the scope of operations, i.e., desire to save money

Having set sustainability as a goal for its installations and their facilities, one of the significant questions the Army has is, "What makes a facility sustainable?" As a concept, sustainability has been touted as a means of "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, quoted on the front cover of *Sustainable Design and Development: A Guide for Army Garrison Commanders* – ACSIM 2000). This definition brings out two primary considerations for Army personnel seeking to implement the concept: the notion of meeting today's needs, and making sure that the means and methods of meeting those needs do not have adverse impacts on the ability of future humans, including the Army of the future, to meet their needs.

Given this definition, it is clear that courses of action that do not meet the Army's needs today are not sustainable. What is less clear is how the Army should go about meeting the requirements of its mission without negatively impacting the ability of future generations to meet their own needs. Specifically, how do decisions made at multiple levels (from doctrine to policy to operations) have the potential to impact future generations? In the case of built facilities, what actions *now* might reduce or eliminate options for meeting human needs in the future? How should courses of action be set to ensure that the outcome of those actions is sustainable?

In the context of this study, a "sustainable facility" is one for which the current and probable future states of the facility cause no net negative impacts to resource bases or ecosystems (the two means by which humanity now and in the future will meet its needs), while satisfying the needs of its stakeholders[2]. To further the goal of Army sustainability, this study considered the challenge of creating a built environment to meet two specific stakeholder needs of today's Army:

- Providing a facility to effectively house the operations and activities of AEPI; and

[1] These drivers, along with relevant legislation and other influences on Army policies and procedures, are documented in more detail in Tab 1 of the accompanying Resource Guide.

[2] A detailed derivation of this definition of facility sustainability, along with additional discussion of its impacts for built facilities, can be found in Tab 2 of the accompanying Resource Guide.

- Putting an abandoned, historically significant building at Fort McPherson back into beneficial use.

Together, these needs represent the core requirements that must be met by the project design and delivery of Building 170. In order for the Building 170 project to be sustainable, it must meet these two needs while not negatively impacting, either now or in the future, the resource bases and natural ecosystems on which present and future humans rely to meet their own needs. The challenge of this study, then, is to articulate the details of both the potential impacts of the facility and the needs of its stakeholders in a way that allows these variables to be evaluated for different possible facility designs. The purpose of this study is to demonstrate a systematic method for doing so, in the context of developing a design solution for Building 170 at Fort McPherson.

1.2 Who Should Read this Report

The primary audience for this report is the stakeholders and decision makers of the Building 170 project. By demonstrating systems-based sustainability analysis to assist in the design of the project, this study has helped to identify important considerations for both the project delivery process and the design of the project itself. These considerations, if incorporated, may contribute to a more sustainable Building 170 that better meets the needs of its stakeholders while minimizing its negative impacts on the ecosystems and resource bases on which it depends.

A second audience for this report is the personnel responsible for making decisions about the planning, design, construction, operations, maintenance, and end of life cycle of other Army capital facilities, including the U.S. Army Corps of Engineers (USACE) and Army Garrison Commands. The methods described in this report are one way to systematically incorporate sustainability considerations into project planning and design, thus meeting Army requirements for sustainable design and development. The report provides an example of how these methods can be used in the context of a real project and points out considerations both for the facility itself and the process used to deliver it that can be extended to apply to other Army projects.

A third audience for this report is Army and Federal policy makers, including personnel from the Assistant Chief of Staff for Installation Management (ACSIM), the Deputy Assistant Secretary of the Army (DASA) for Installations and Housing, and the Army Environmental Policy Institute (although these personnel also are direct stakeholders of the facility analyzed in this study). Some of the recommendations of this study can only be implemented with changes in Army or Federal policy, and thus the contributions of these policy makers will be required to develop appropriate policy and procedures to facilitate the implementation of sustainability concepts throughout the Army.

A final audience for this report is the research and development community dedicated to developing new technologies and strategies for the built environment. In the context of Building 170, this report highlights some of the best available technologies and strategies for increasing built facility sustainability. It also describes areas in which research and development (R&D) are needed to develop the technologies and strategies necessary to create truly sustainable built facilities. This audience should consider the R&D recommendations in this report as a starting point for creating the solutions necessary to achieve sustainability not only at the facility level, but at the installation, community, and global levels as well.

1.3 Background

Before describing the objectives, methods, and results of this study, the background and point of departure of the study must be established. The following subsections describe the evolution of this project in terms of the two key needs that resulted in definition of the adaptive reuse of Building 170 as a solution (AEPI's facility-related needs and Fort McPherson's historic preservation needs), resulting goals for the Building 170 adaptive reuse project, and prior studies undertaken toward meeting those goals.

1.3.1 The Need for Adaptive Reuse of Building 170

The Army Environmental Policy Institute (AEPI) plays a leading role in the Army's effort to achieve its mission in an environmentally friendly manner, thus ensuring the health, safety, and welfare of the nation and the resource bases and natural ecosystems upon which it depends. AEPI's mission is "to develop policy options and recommendations to better integrate environment with the Army mission" (AEPI 2000). AEPI's overall objectives are to "sustain readiness, improve quality of life, strengthen community relationships, and help reduce total cost of ownership by suggesting sound environmental investments for force modernization" (ibid.). To achieve these objectives, AEPI lists the following responsibilities as part of its overall role within the Army:

- Analyzing future environmental challenges and opportunities, particularly those that may impact Army mission and readiness;
- Executing research and analysis as a basis for developing environmental policies and strategies;
- Assessing the costs and benefits to the Army of alternative policies.

One of the key focus areas of AEPI's work has been to investigate policies and strategies for sustainable military installations. AEPI's interest in the sustainability of installations stems from its recognition that installations are the foundation of the Army's ability to achieve its own mission. AEPI's interest in sustainable installations includes investigations into the environmental and economic impacts of installations and the facilities and infrastructure that comprise them. As part of this function, AEPI is particularly interested in developing new policies to guide sustainability improvements at an installation scale, and establishing tools and methods to support the implementation of those policies.

Since 1999, AEPI has been aware of a notable opportunity to demonstrate sustainability principles in practice: its future headquarters in Building 170, Ft. McPherson, GA. This future home for the Institute is an ideal opportunity to showcase state-of-the-art sustainable building technologies and strategies and their application in the day to day operations of a military organization. Building 170 was identified as a new home for AEPI in 1999 as an opportunity to displace its current use of Class B leased office space in downtown Atlanta. The building, originally designed and built as a medical clinic and hospital in 1930, is a classic example of the population of historical buildings that exist on many installations in the United States and elsewhere. Located within the historic district at Ft. McPherson, the building is presently unoccupied and falling into disrepair. Due to its position in the historical district and the nature of its construction, the building is not replaceable using modern construction methods and its loss would significantly degrade the historic district. Adaptive reuse of the building as office space for AEPI will address two needs:

- The need to reduce or eliminate the cost of leasing privately-owned office space to house AEPI
- The need to establish a beneficial use for a historically significant building to justify the cost of renovation of the facility

1.3.2 Goals for the Building 170 Adaptive Reuse Project

Given its interest in sustainable facilities as part of work in sustainable military installations, AEPI feels that restoring the building using sustainable facility technologies and strategies would accomplish goals relevant to its mission as follows:

- Create a living example of state-of-the-art sustainable building technologies and strategies that will serve as a role model for future Army building activities
- Demonstrate the core values of AEPI to its personnel and their visitors
- Develop an alternative to existing practices for historically significant structures, which at present are often overlooked in lieu of construction of new facilities due to perceptions of excess cost and design and construction challenges

Form 1391 was filed with the Army in July 2000 to establish a need and obtain funds for renovating Building 170. To encourage the use of state-of-the-art sustainable facility technologies and strategies and maximize the sustainability of the resulting building, AEPI commissioned a series of studies to supplement the traditional programming and design processes used by the Army for such projects. The next section describes these studies and summarizes their outcomes.

1.3.3 Prior Studies on Building 170

Prior to the study described in this report, AEPI has commissioned three other studies to analyze Building 170 and identify opportunities for sustainability improvement: an initial case study analysis of the state of the building including limited improvement recommendations; a sustainable design workshop/charrette that brought together over 20 experts on various aspects of facility sustainability to develop detailed improvement recommendations; and a deconstruction analysis of the building that identified likely solid waste streams from the building renovation and potential destinations for those streams [3].

To begin the development of an alternative, sustainable construction plan for Building 170, AEPI commissioned Southface Energy Institute (an Atlanta-based nonprofit organization specializing in energy efficiency and green building technologies) to develop a case study analysis of the building in its then-current state as the foundation for a sustainable design workshop to develop sustainable design recommendations for the facility. This initial case study (Southface 2000a) provided:

- A review of existing conditions at the facility (including photographs, as-built plans and elevations, and narrative descriptions);
- Computer simulations of building energy performance in its then-current condition;
- Computer simulations of building energy performance under four possible upgrade scenarios: building envelope improvements, energy efficient lighting upgrade, HVAC upgrade, and combination of all three;
- Considerations for sustainable design of an adaptive reuse plan for Building 170, including challenges given the existing conditions of the building, suggestions for reuse and recycling of selected building materials, specific technologies that might be employed, and life safety and accessibility issues; and
- An overview of physical space and functional requirements for the new space based on a recent needs assessment of AEPI's requirements performed by Southface.

After Southface completed its initial case study analysis of Building 170, AEPI commissioned a charrette of local and national sustainability experts to be facilitated by personnel from Southface Energy Institute. These experts came together at Fort McPherson for a two and a half day working session to evaluate the current condition of Building 170, identify goals and objectives for transforming it into a showcase sustainable facility, and describe specific technologies, design features, and approaches to implement the required retrofits in the building. Along with AEPI and installation staff, the experts worked together in three subgroups to identify solutions with respect to energy, water/site, and materials/indoor environmental quality. Throughout the session, formal and informal cross-feed among working groups ensured that design recommendations were not in conflict with one another and that these solutions were integrated to the greatest degree possible. The outcome of this charrette was a report and briefing on the possibilities for Building 170 to become a showcase sustainable headquarters for AEPI.

Four guiding objectives were initially established by Southface to guide the charrette process and its participants. The goal of the charrette was to develop a plan for the building that (Southface 2000b):

- Preserves and enhances the building's historic qualities
- Provides a quality work environment for AEPI
- Creates an accessible educational tool to promote green building technology
- Minimizes the building's environmental impact (maximize pollution prevention)

The charrette process was structured strongly around the Leadership in Energy and Environmental Design (LEED) Green Building Rating System, version 2.0, developed by the U.S. Green Building Council and quickly becoming the de facto measurement standard for green building in this country (USGBC 2000). The LEED system consists of five categories of issues (site, water, energy, materials, indoor environmental quality), in which buildings can receive multiple points based on the degree to which they meet or exceed stated performance requirements in each category. LEED was selected as a basis for structuring the charrette for several reasons, including its de facto status for sustainability evaluation and its ease of use (LEED points are clearly and quantitatively defined as performance thresholds that must be met or exceeded). The charrette facilitators also had strong reason to believe that LEED will

[3] Additional synthesis and summary information about Building 170 derived from review of building documentation and interviews can be found under Tab 3 in the accompanying Resource Guide.

soon become a basis for design of Army projects, since the Army Corps of Engineers has commissioned its Engineering Research and Development Center (formerly the Construction Engineering Research Laboratory) to adapt this system as a basis for the development of a Sustainable Project Rating Tool (SPiRiT) that will be used in future Corps construction projects. Not only were working groups structured into similar categories of issues, but also LEED points were used as a minimum performance standard for the proposed facility with respect to solutions developed by the working teams.

The outcome of the charrette was a final report (Southface 2000b), resource packet, and briefing that describes:

- An overview of the workshop, including project objectives
- Description of existing conditions (which is a summary of findings from the case study analysis)
- Sustainable design recommendations in the major categories of: 1) Sustainable site and water use; 2) Green architecture and materials; and 3) High-performance energy systems. Each category also includes a discussion of Integrated Fort McPherson Strategies that involve more than Building 170 and address issues of sustainability on a larger scale
- Evaluation of proposed retrofits in terms of life cycle economic impacts, projected performance according to the LEED rating system, and equity value of green design
- Technical details and additional information for selected strategies identified in the report

Revised building energy performance simulations were also completed based on additional information identified during the charrette, the results of which are documented in Southface's final project report. If the project were to be executed using all of the recommended sustainability strategies identified during the charrette and described in the report, Southface staff have estimated that the project would be able to achieve a LEED Gold rating (on a scale from lowest to highest including unrated, LEED Rated, LEED Silver, LEED Gold, and LEED Platinum).

Following the charrette and in conjunction with Georgia's Pollution Prevention Assistance Division (P2AD), AEPI commissioned a deconstruction analysis to be performed by Brad Guy, a deconstruction expert from the University of Florida. Mr. Guy performed a walk-through of the building with P2AD personnel and selected demolition contractors to identify candidate waste streams that can be recovered or recycled during the retrofit construction process. The following candidate waste streams were identified as having the potential to be recovered or recycled: brick, cabinets/benches, carpet, ceiling tiles, fluorescent lamps, and metals (Guy 2000).

For each waste stream, companies were identified (along with contact information) that will accept the wastes and comments were provided that identify additional considerations (such as legal ramifications, technical requirements, and economic paybacks if known). Since recovery of waste was one of the fundamental strategies identified in the design workshop, this additional study provides a mechanism for carrying out the recommendations of the charrette participants in this area.

1.4 Project Objectives and Outcomes

As a result of the three studies, AEPI has obtained a set of recommendations pertaining specifically to Building 170 that identify strategies and technologies to be applied in the project. However, prior work has not performed two key tasks that will aid AEPI in achieving its objectives for Building 170:

- Identifying how sustainable Building 170 will be as a result of implementing the recommendations in prior studies, and
- Documenting a generalizable process for identifying sustainability improvement options that will achieve sustainability goals for other building projects

The study described in this report was commissioned by AEPI to execute these tasks. The objectives of this project were four-fold:

- To determine if any improvements can be made to the recommendations prepared by the working groups of the charrette for retrofit of Building 170

- To identify existing best available technologies and strategies that could be implemented to improve the sustainability performance of the proposed retrofit

- To delineate areas where research and development is needed to provide new technologies and strategies to improve sustainability performance

- To compare the outcomes of LEED-based solution development with systems-based solution development

There are two primary outcomes of this project:

- A set of recommendations related to Building 170 identifying ways in which the sustainability of the proposed retrofit can be improved through existing and yet-to-be-developed technologies and strategies

- Demonstration of the process of systems-based sustainability analysis as the foundation for the design and development of sustainable Army facilities.

The next chapter describes the method used to accomplish the objectives of the study: the implementation of a systems-based sustainability analysis to identify opportunities for improving the sustainability of the project and develop recommendations for future research and development.

2.0 Method

The goal of this project was to identify strategies and technologies (existing or yet to be developed) that can be used to make Building 170 more sustainable. The key to achieving this goal is to be able to measure the relative sustainability of different possible configurations of Building 170 (hereafter denoted "system states"), so that the effects of different alternatives on the sustainability of the building as a whole can be compared and the most sustainable configuration can be recommended.

2.1 Overall Approach for Systems-Based Sustainability Assessment

To achieve the project goal, a systems-based sustainability assessment method was used to model the relative sustainability of three different facility states:

- A baseline or status quo state of the building, defined as how the renovation would be done using typical building methods without specific consideration of sustainability.
- The proposed retrofit state of the building, defined as how the renovation would be done if all recommendations of previous studies were incorporated. This corresponds to a LEED Gold rated building.
- The ideal sustainability state of the building, defined as how the building would behave if all sustainability objectives and constraints were exactly met.

To identify improvements to the proposed retrofit state, the ideal sustainability state was defined from a performance standpoint, and this served as a starting point for working backward to define gaps between the proposed retrofit and the ideal states. Based on the scope delineated for this project, Building 170 is sustainable if it meets the following criteria AND falls within any feasibility constraints imposed on the project:

- Stakeholder Satisfaction $\geq$ Basic needs met
- Resource Base Impact $\geq$ No or neutral impacts
- Ecosystem Impact $\geq$ No or neutral impacts

Figure 2.1 provides a graphical representation of these three criteria considered together, with each criterion being represented by one axis in three-dimensional space. The intersection of the axes represents the point at which each criterion is met exactly, i.e., Stakeholder Satisfaction = basic needs met AND Resource Base Impacts = no or neutral impacts AND Ecosystem Impacts = no or neutral impacts. This point represents the absolute minimum conditions for sustainability, i.e., the threshold between sustainability and unsustainability. The shaded area, representing the positive region of all three axes, illustrates the conditions under which all three criteria are positive, and any system state in this area meets or exceeds the minimum requirements of sustainability. All other areas in the diagram represent cases in which at least one of the criteria is unsustainable. Building 170 would be sustainable if it falls anywhere within the octant of sustainability depicted in the diagram.

The purpose of systems-based sustainability assessment is to determine how a given state of a built facility performs in terms of the three criteria. Once this is known, the sustainability state of the system could be plotted in a three-dimensional representation to indicate its composite sustainability. However, in this analysis, each of the three criteria was considered separately, and any violation of any of the requirements was identified as unsustainable.

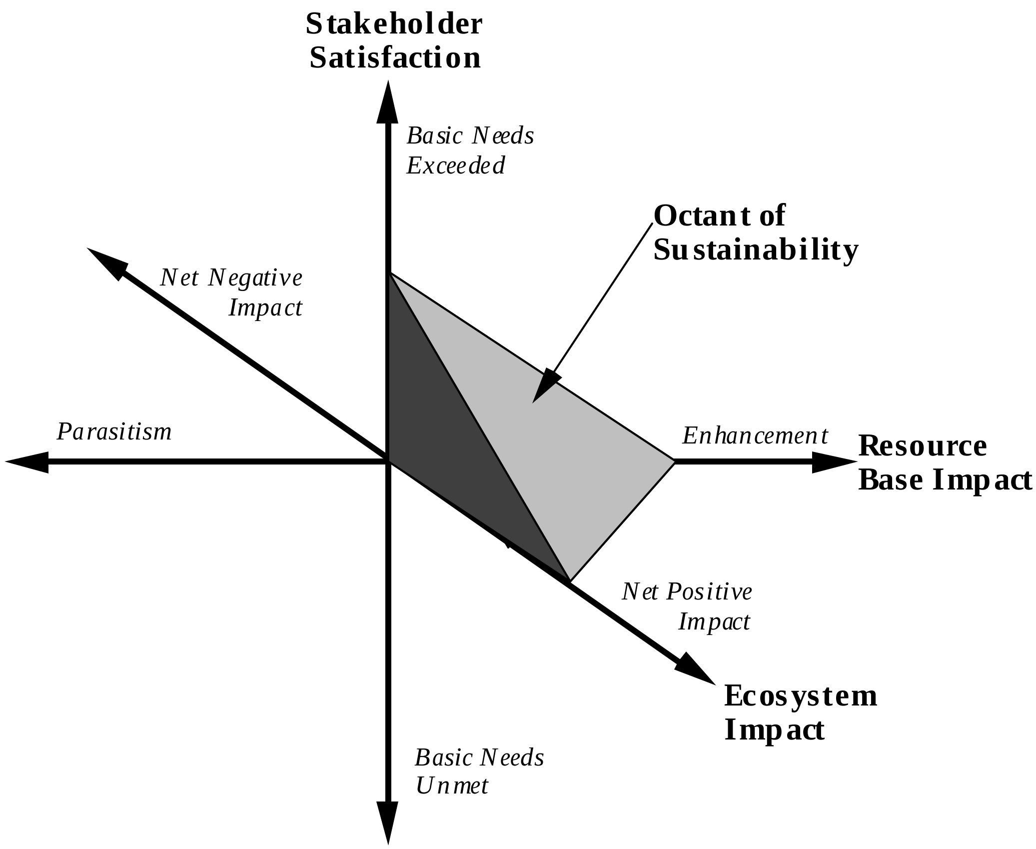

Figure 2.1: Systems-based Sustainability Criteria (Pearce 1999)

To determine the relative sustainability of different states of Building 170, we need to know how the building performs with respect to the three criteria that define sustainability for a built facility, represented by the three axes of the diagram in Figure 2.1:

- <u>Stakeholder Satisfaction</u> – how well does the facility meet the needs and aspirations of its stakeholders? Does it meet their expectations well enough that stakeholders do not take compensating actions that would reduce sustainability?[4]

- <u>Resource Base Impacts</u> – does the construction or operation of the facility contribute to the degradation or depletion of resource bases? If so, is that negative impact ameliorated either by natural regeneration of the resource base itself[5], or through some compensatory positive impact of the facility system?

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[4] Satisfaction of stakeholder needs and aspirations is a difficult condition to define, let alone measure. In the case of the sustainability assessment method used in this work, satisfaction is defined as a state in which the building stakeholders do not take compensating actions to improve upon the building's ability to meet their needs and aspirations. For example, if the lighting in the building meets stakeholder needs, then building occupants will not need to bring in their own lamps to improve the lighting. However, if lighting is unsatisfactory in terms of the needs and aspirations of the building occupants, then they might add separate lamps to their offices to supplement the lighting provided by the building. This compensating action would increase the electrical loads of the building and therefore decrease the overall sustainability of the building. The goal of sustainability seeks to create a building that does not encourage or require its users to make modifications (with associated unpredictable or negative sustainability impacts) in order to have their needs and aspirations met.

5 Methods exist to certify that materials are "sustainably harvested" from resource bases, most notably Scientific Certification Systems' certified sustainably harvested lumber. Sustainable harvest means that materials are not taken from resource bases at a

- Ecosystem Impacts – does the construction or operation of the facility contribute to the destruction or degradation of natural ecosystems? If so, is that negative impact ameliorated either by natural recovery of the ecosystem itself[6], or through some compensatory positive impact of the facility system?

If the sustainability of a facility system can be estimated in terms of these three factors, then different design alternatives of the facility can be compared in terms of their relative sustainability, enabling designers to choose the most sustainable alternative among the set of options considered. In this project, the key factors affecting the sustainability of Building 170 were compared for the three system states, and alternatives were explored that could improve the sustainability of the proposed retrofit state of the building.

The overall assessment method used in this work is depicted in Figure 2.2. First, the three states to be compared were defined as listed earlier: the baseline/status quo state (to provide a benchmark for sustainability performance and establish a scope of analysis), the proposed retrofit state (defined by the recommendations of previous studies), and the ideal sustainability state (defined as how the building would behave if it were to exactly meet sustainability requirements). Specific information about the building and stakeholder attributes that affect the three sustainability factors (stakeholder satisfaction, resource base impact, and ecosystem impact) was collected and used to create a systems model/profile of each of the three states for purposes of comparison[7]. The differences across the three profiles (determined from the systems models) were used to construct a gap analysis to indicate in what ways the proposed retrofit state was different from the ideal sustainability state. The outcome of the gap analysis was expressed in the form of sustainability improvement opportunities, which were used to search a pool of Best Available Technologies and Strategies (BATS) relating to sustainable facilities. BATS applicable to the opportunities presented by Building 170 (indicated on the left side of Figure2.2) were subjected to a feasibility analysis to determine if they met constraints identified by stakeholders. All BATS that met constraints were kept for further analysis, while infeasible BATS were discarded. Cost-benefit analysis was used on the feasible BATS to prune any solutions that were not cost-effective, and to prioritize remaining BATS into a set of recommendations for improving the sustainability of Building 170.

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rate faster than they replace themselves, and that the methods used for harvesting do not compromise the quality of the resource base or its ability to regenerate itself. In essence, this means that the quantity and quality of available resources do not change from year to year.

[6] As with natural regeneration of resource bases, ecosystems have the ability to recover on their own from negative impacts induced by human actions. This ability is contingent upon not exceeding certain thresholds of impacts beyond which the ecosystem is so taxed that it begins to degrade over time. This threshold is called the carrying capacity of the ecosystem, and has been the subject of extensive study. The specific carrying capacity of an ecosystem is difficult to quantify, since many of the symptoms of ecosystem degradation appear long after the root cause has already occurred. Thus, an ecosystem might appear to be healthy when in fact it has already been compromised – the delay in appearance of symptoms can lead to incorrect conclusions about the true integrity of ecosystems.

[7] Details regarding the profiles and systems models for each of the three systems states can be found in Appendix A to this report. The overall findings are discussed in Chapter 3.

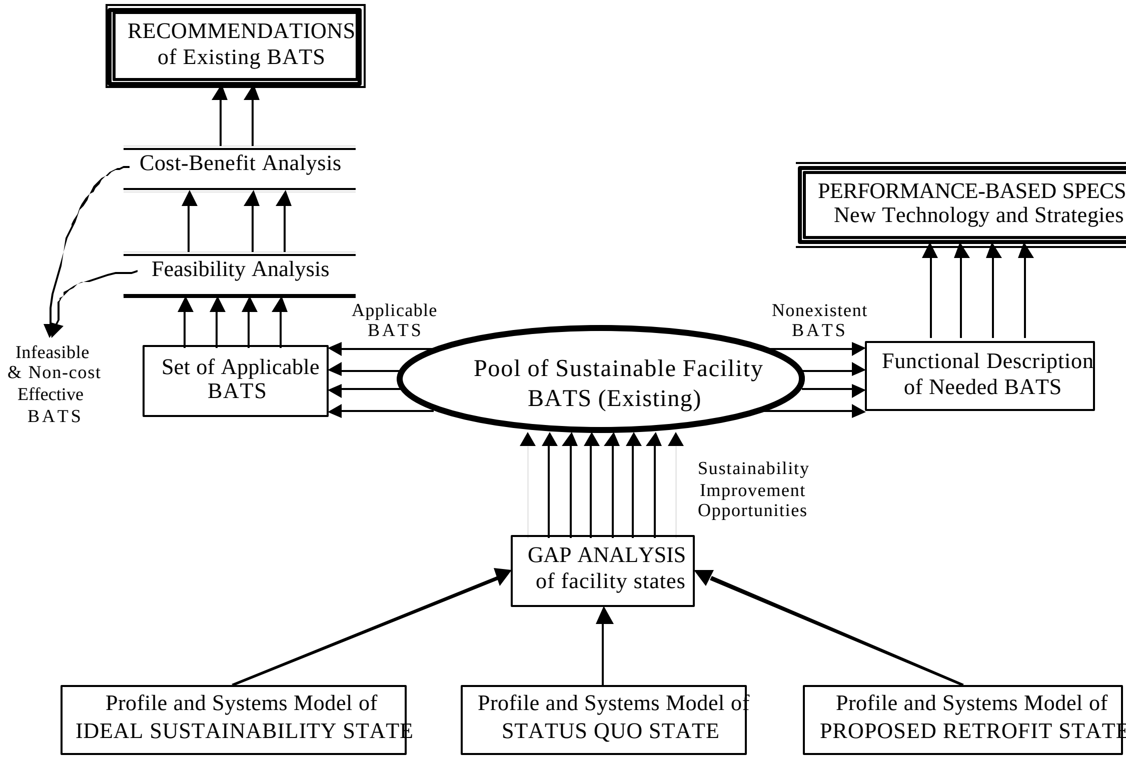

Figure 2.2: Overall Assessment Method

Some sustainability improvement opportunities were not able to be addressed by existing technologies and strategies. These opportunities represent needs for *new* technologies and strategies that should be developed to improve our ability to construct sustainable facilities in the future. These opportunities (indicated on the right side of Figure 2.2) were expressed in terms of functional requirements that translate into performance-based specifications for the research and development of new sustainable facility technologies and strategies. This set of specifications comprises a research agenda for development of new technologies and strategies, one of the key objectives of this project. The following subsections describe each step of the overall method in greater detail.

2.2 Profile Development, Systems Modeling, and Gap Analysis

Figures 2.3 and 2.4 show the status quo systems models for the construction and operations/ maintenance phases of Building 170's life cycle, respectively. Development of these models for each system state is the first step in defining what sustainability means specifically in terms of Building 170 and its environment.

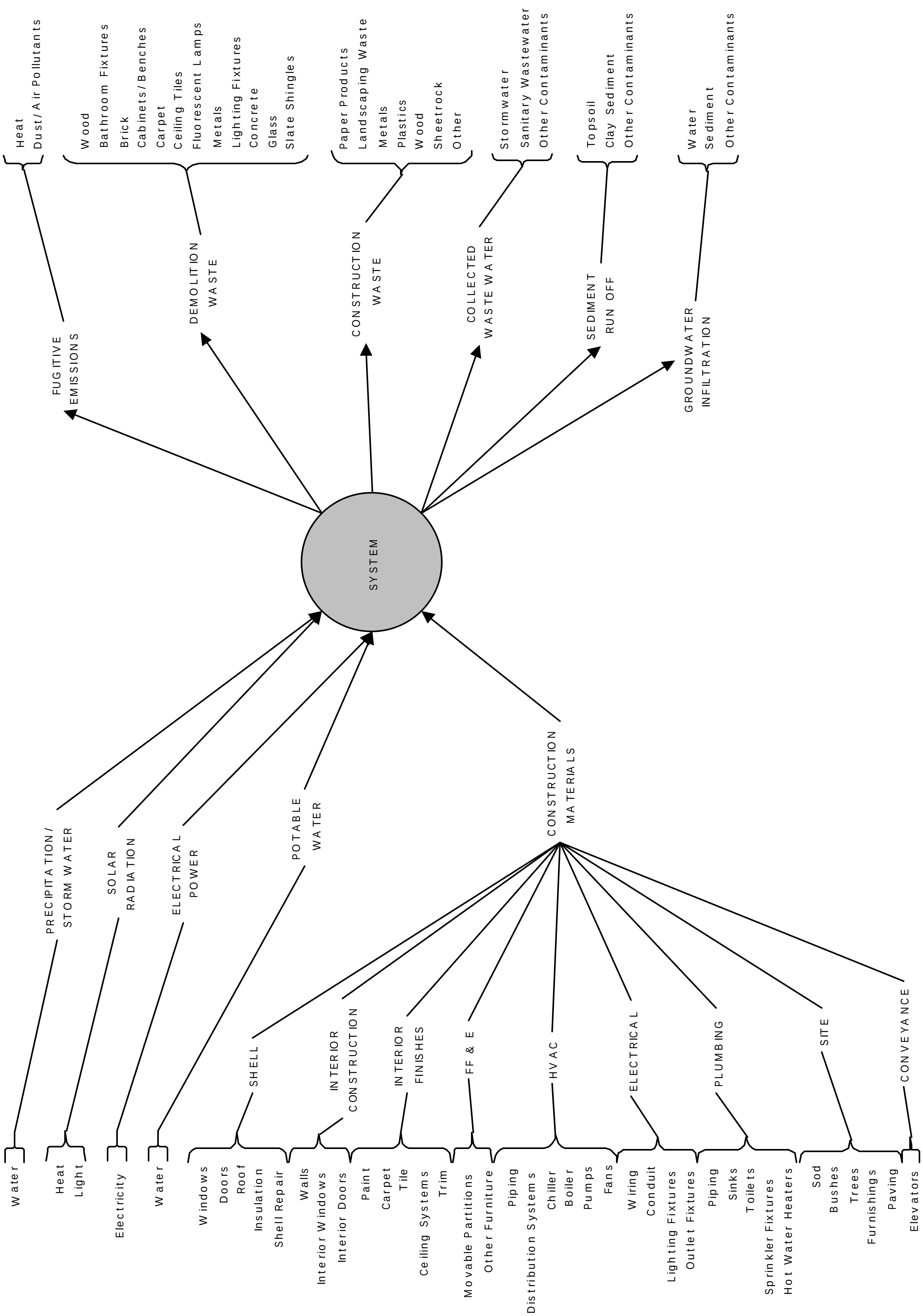

Figure 2.3: Status Quo Systems Model for Construction

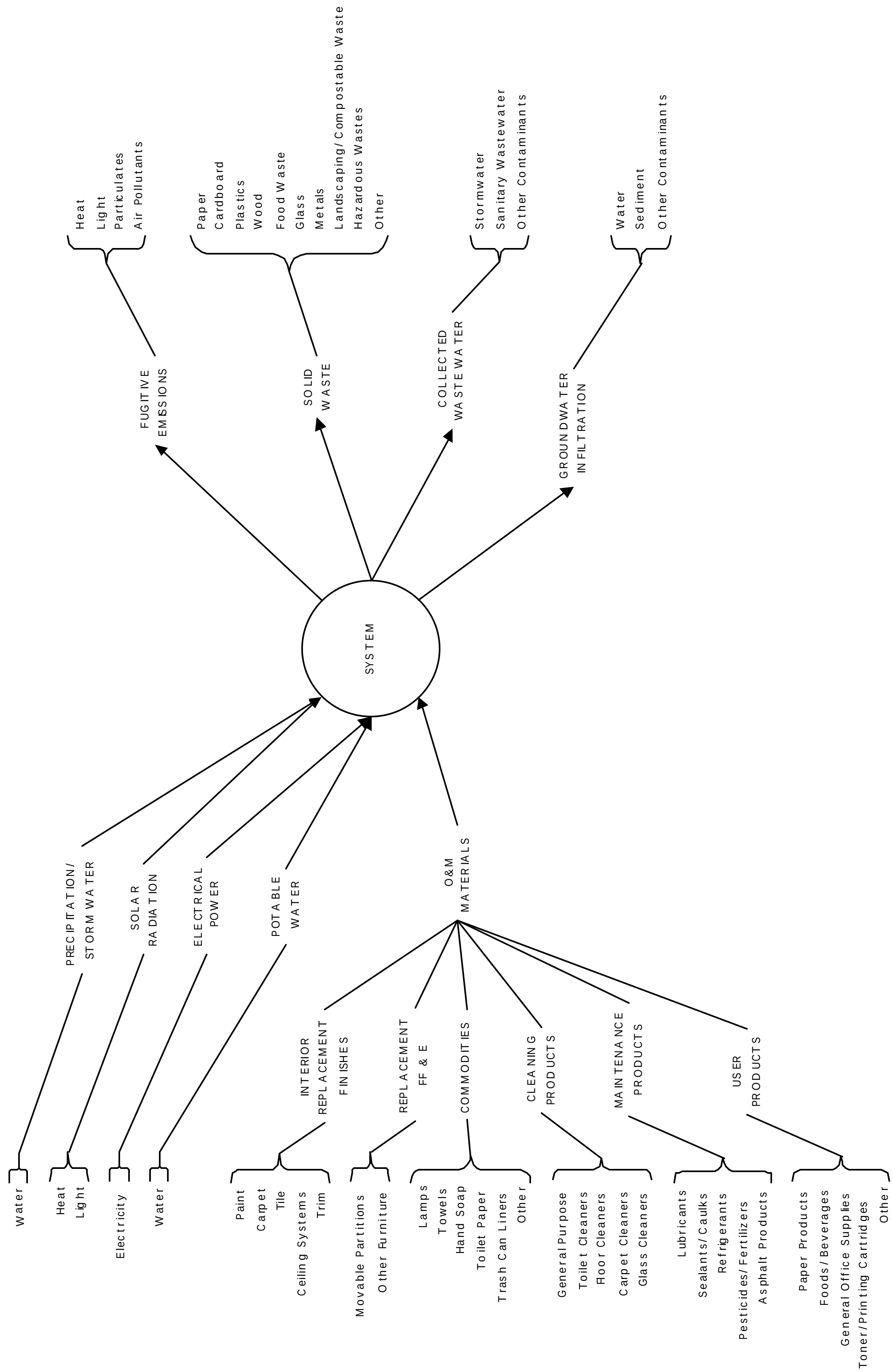

Figure 2.4: Status Quo Systems Model for Operations & Maintenance

The process begins by defining a boundary for the system to be analyzed, which in this case is Building 170 and its associated grounds and parking areas.[8]. This boundary and the system it encloses is indicated in the systems models by the shaded circle in the center of the diagrams (see Figures 2.4 and 2.5, for example). The goal of systems modeling is to systematically identify the facility's impacts to resource bases and ecosystems for each system state, so that the system states can be compared in terms of how well they meet sustainability requirements.

To identify impacts caused by the facility, potential flows of matter and energy were identified for each of the system states. At this phase in the design of project scenarios, many flows could be identified only in general, and determination of actual quantities and specific sources or sinks was impossible. Therefore, detailed calculation of specific impacts could not be accomplished due to lack of data. However, the objectives of the study (comparison of system states and identifying opportunities for improving sustainability) could still be accomplished by looking at likely *differences* across system states, and adequate information was available to identify these differences. These differences are identified from profiles developed for each system state, which list likely flow types, sources and/or sinks, quantities (expressed in relative terms with respect to the status quo model), and likely impacts caused by the generation or absorption of flow by source or sink systems. Appendix A to this report contains the profiles of Building 170 for four different aspects of each state: Construction Inputs, Construction Outputs, Operations & Maintenance Inputs, and Operations & Maintenance Outputs. The ideal sustainability state is portrayed in profile not by specific *quantity* of flow, but rather by noting that all impacts resulting from flows must equal zero, i.e., there must be either: a) no negative impacts to resource bases or ecosystems that are not exactly offset or exceeded by positive impacts, or b) no negative impacts at all associated with each flow.

Gap analysis is the outcome of systems modeling, and involved comparing the likely impacts for each flow type against the corresponding impacts for other system states. For each flow, the impact in the ideal sustainability state is set to equal zero, and the likely impacts from other states are plotted with respect to that goal. Appendix B contains overall comparisons of the state profiles, and gap analysis charts of the relative sustainability of the three system states. All flows for which the proposed retrofit state has less than sustainable impacts were indicated by shading in the gap analysis charts. These flows represent potential sustainability improvement opportunities, which were further explored in the next part of the analysis.

2.3 Articulation of Sustainability Improvement Opportunities

Each of the gaps identified in the gap analysis represents a sustainability improvement opportunity for the facility. To begin to identify specific ways to bridge the gaps, the next step was to identify what are the *drivers* of negative impacts that prevent the proposed retrofit state from meeting the requirements of the ideal sustainability state. This process is called Impact Chain Analysis, and works by tracing identified impacts of the facility system back to their root cause(s) within the system itself. Using the graphical notation of systems modeling as illustrated in Figures 2.3 and 2.4, Figure 2.5 shows how flows coming into the system from an Affiliate System (indicated by "AS") are related to impacts (indicated by arrows coming into the affiliate system) that stem from that system's generation of flow (indicated by the arrow coming *out* of the affiliate system. Note that the same effects apply to sink systems, in which flows arrive *from* the facility system and impacts are generated as the sink absorbs those flows. While the diagram shows only impacts from inputs to affiliate systems, impacts can also result from the outputs of affiliate systems; those impacts are not represented in the diagram for visual clarity.

The exploded view of the flow entering the system (shown in the lower right portion of the figure) shows how flows are drawn into the system by components or sub-systems that use that flow to meet the functional requirements of stakeholders. An example of this transaction is the import of electrical power by building HVAC systems in order to heat, ventilate, and cool the building and meet thermal comfort and air quality requirements of stakeholders. The electricity itself comes from the grid which is supplied by multiple power sources. The power source most likely to supply most of the grid power for Fort McPherson are fossil fuel-fired power plants, the impacts of which include depletion of non-renewable resources (fossil fuels) and degradation of air quality due to combustion by-products. The energy consumed by Fort McPherson is responsible for a share of these impacts proportional to the amount of

[8] An initial site boundary was established by the Southface team as part of its sustainable design workshop. This boundary is indicated on site plans included in (Southface 2000b). Since this boundary was the basis for all calculations pertaining to the proposed retrofit state of the facility, it has been kept as the boundary for defining the system in this analysis as well.

energy consumed. Reduction of energy requirements by Building 170 correspondingly reduces the share of negative impacts that are attributed to the system.

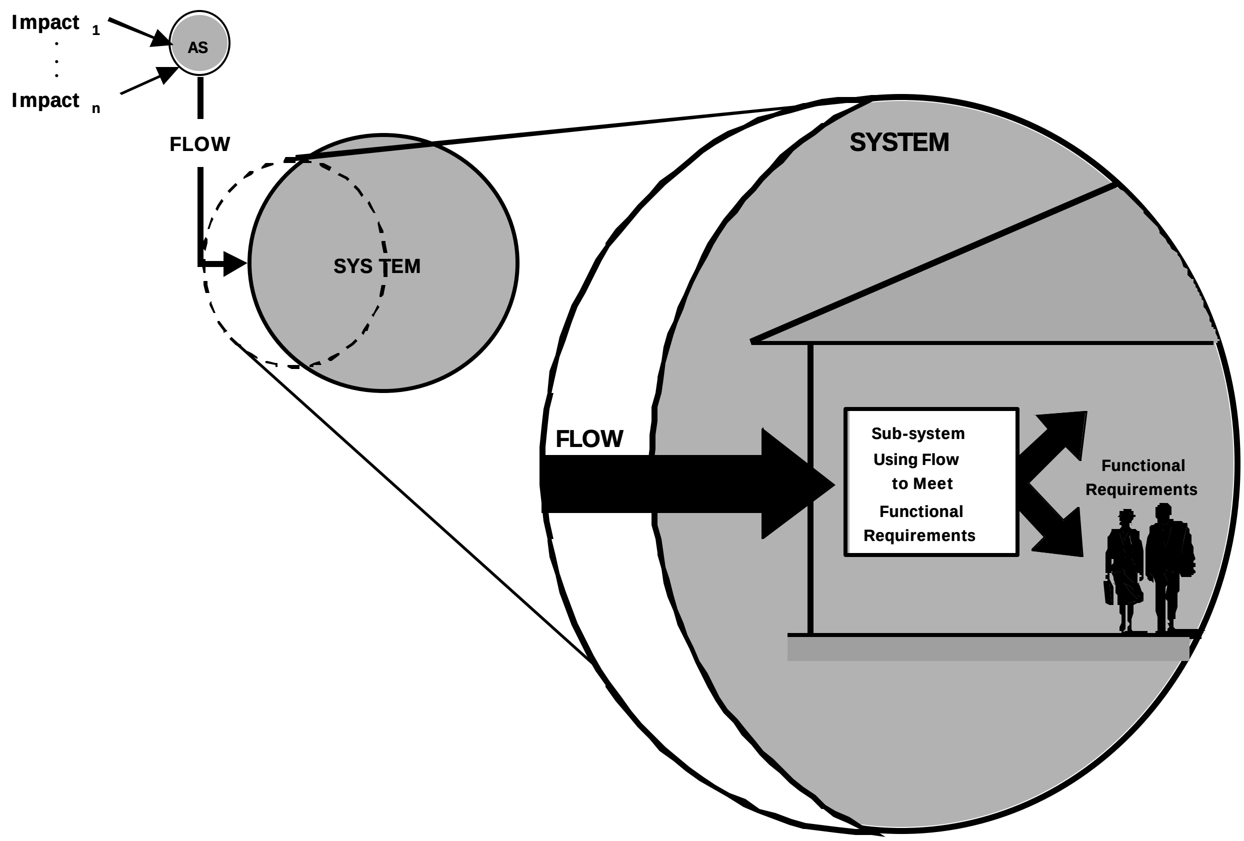

Figure 2.5: Impact Chain Analysis

The series of {functional requirements -> sub-system function -> demand for flow -> production of flow -> impacts generated by production} represents the impact chain associated with whatever flow is under consideration. For the HVAC example, the impact chain is:

- Thermal comfort/air quality needs are met by…
- …Building HVAC systems, which require…
- …Electrical power to operate, which ultimately comes from…
- …Fossil fuel-fired power plants, which have impacts of…
- ….Resource base depletion (fossil fuel use) and Ecosystem degradation (air pollution), which means that…
- …the system needing the flow of electricity from this source is unsustainable.

Similar impact chains can also be constructed for downstream flows and sink systems. Different links in an impact chain can also connect with links in other chains. For example, the second link in the HVAC impact chain, denoted as item 2 in the list above, also connects to impact chains for all the other substances that HVAC systems require in order to produce thermal comfort and air quality, such as a supply of new air filters. Likewise, the first link in the chain (thermal comfort and air quality) also connects to other links besides the HVAC system, such as operable windows or the building envelope.

The result of impact chain analysis can be a complex web of connections linking user functional requirements with the building components that provide them and the affiliate systems that provide the matter and energy needed to construct and operate those building components. Impact chains were constructed for each of the major groups of unsustainable flows associated with Building 170 to pinpoint where interventions could be made that would reduce, eliminate, or offset any negative impacts of the proposed retrofit state. Appendix C contains these impact chain descriptions. The next section explores the ways in which impact chains can be used to identify specific technologies that will improve the sustainability of the facility as a whole.

2.4 Search for BATS that Address Sustainability Improvement Opportunities

Having identified specific opportunities to improve sustainability in the form of impact chains explaining the causes of negative impacts, the next step was to seek out ways to reduce, eliminate, or offset negative impacts associated with Building 170's proposed retrofit state. This process involved reviewing the knowledge base of existing Best Available Technologies and Strategies (BATS) for sustainable facilities to search for matches for each opportunity. The knowledge base used for this review included Georgia Tech's sustainable facilities heuristics database and library of sustainable facilities and infrastructure resources.[9] For each opportunity, potential applicable BATS were identified that might improve the sustainability performance of the resulting facility, i.e., reduce some negative impact caused by the facility as identified in the profiles. Figure 2.6 illustrates eight different strategies for minimizing, eliminating, or offsetting negative impacts associated with specific impact chains connected to the facility system. These strategies are divided into four categories:

- First-order Strategies – these strategies are ones that should be examined first in seeking to increase the sustainability of the system. Since they involve actions that can be taken directly *inside* the boundary of the system, they offer maximum control of outcomes by stakeholders and, correspondingly, the least amount of risk.

- Second-order Strategies – these strategies involve changing the sources or sinks of flows or the kinds of flows themselves in order to reduce negative impacts. These are the second course of action since they offer some control over outcomes by stakeholders (who get to choose for the most part what products they want to use and from whom, i.e., purchasing power for goods and services). However, since the behavior of the sources and sinks is out of direct control of stakeholders, there is some measure of risk involved.

- Third-order Strategies – these strategies involve working directly with affiliate systems (which serve as sources or sinks to the facility itself) to help them improve their own sustainability. Compared to second-order strategies, stakeholders have even less control over outcomes and therefore have higher risk of unpredicted outcomes. However, source and sink systems have a vested interest in maintaining their market, so there is some motive on the part of affiliate systems to improve their sustainability if doing so will solidify relationships with their customers.

- Fourth-order Strategies – the final class of strategies consists of finding ways to offset negative impacts of the facility system by improving the impacts of other, unrelated systems. In many instances (e.g., for all new materials and equipment that must be imported during the construction of a facility), this is the only way to reduce net impacts to zero. However, it is a measure of last resort in that it offers the least amount of control to stakeholders and therefore the greatest amount of risk in terms of outcome predictability.

[9] Georgia Tech is a repository of information about sustainable design and facilities/infrastructure best practices. Georgia Tech's sustainable facility heuristics database contains over 5000 knowledge statements from nearly thirty literature compilations of sustainable facilities knowledge. The library used for this work was provided by Georgia Tech's Sustainable Facilities and Infrastructure Program, and contains over 800 volumes pertaining to the built environment, design, and sustainable facilities and infrastructure. While these knowledge bases are not purported to be exhaustive, they do provide a sound, broad basis for generating potential BATS to recommend for the Building 170 project.

For each impact chain, the search for strategies started by seeking first-order strategies that would reduce the impacts of the chain to zero. If no BATS were found that were first-order strategies, then the search proceeded on through second-, third-, and fourth-order strategies until a solution was found that could reduce the impacts of the chain to zero. For cases in which no higher-order strategies were available to reduce impacts to zero, the lack of higher-order strategies represented missing or yet-to-be-developed BATS that were noted as items for the research agenda. Appendix D contains tables describing the strategies identified for each impact chain.

2.5 Development of Sustainability Improvement Recommendations

After all impact chains were evaluated for potential BATS that could reduce their impacts to zero, the next step was to further assess the feasibility, costs, and benefits of all potential BATS that were applicable to Building 170. For these BATS, a conceptual feasibility check was performed to determine if they could be applied without compromising stakeholder satisfaction requirements or other project constraints. Table 2.1 shows stakeholder satisfaction criteria identified from a series of stakeholder group interviews and surveys[10], and Table 2.2 lists known feasibility constraints for the project that were also derived from the interviews and surveys. If a BATS did not meet feasibility constraints, it was eliminated from further consideration.

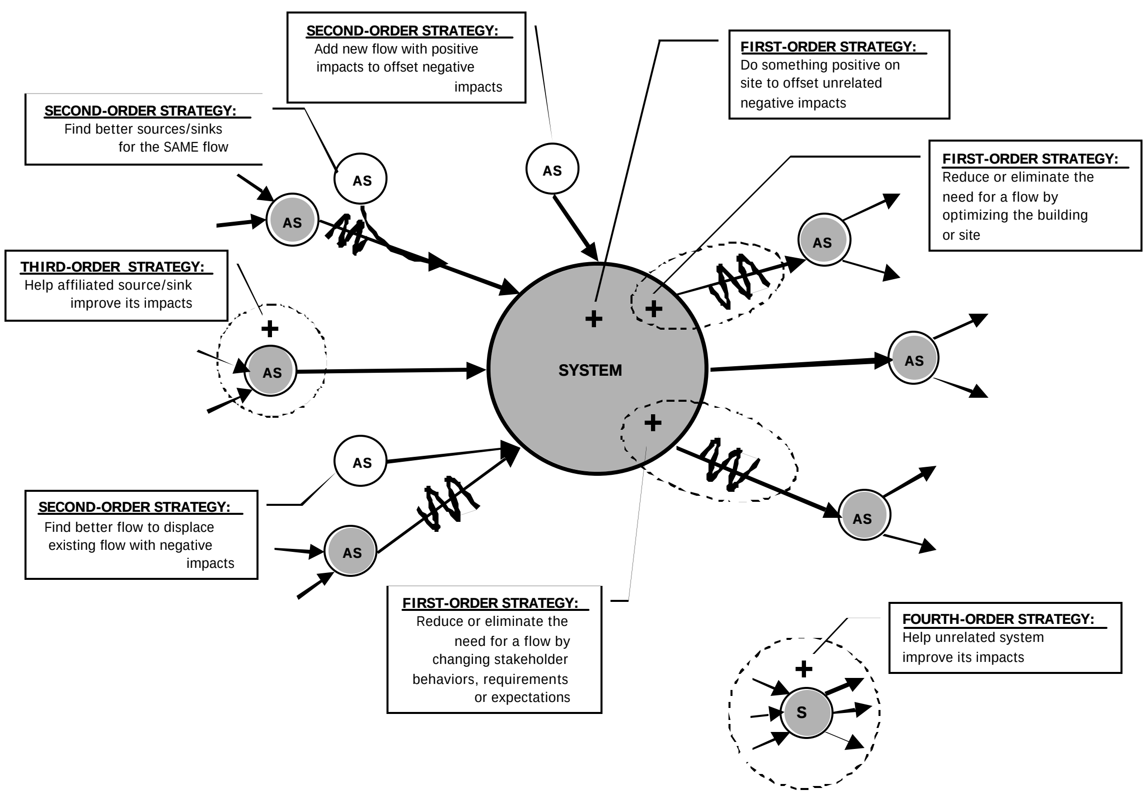

Figure 2.6: The Spectrum of Strategies for Improving Facility Sustainability

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[10] Data collection instruments (surveys and interview protocols), along with summaries of the results of these data collection efforts, are provided in Tabs 5-7 in the accompanying Resource Guide. Stakeholder groups included in the data collection included Fort McPherson Garrison personnel, Army FORSCOM personnel, and staff from AEPI and co-located Army Southern Regional Environmental Office (SREO).

If a BATS *did* fall within feasibility constraints, it was considered in light of the likely cost and effort required to achieve the sustainability improvement provided by that BATS[11]. BATS were also evaluated based on associated risk, reliability, value, and difficulty associated with the kind of strategy being used.

Risk was used as an evaluation criterion in terms of the likelihood that implementing the BATS would actually result in the desired effect. In general, greater control is associated with strategies taking place *inside* the system (first order strategies) than *outside* (all other strategies). Likewise, being a customer of affiliate systems (third order strategies) means greater control over the success of efforts to improve those systems than if there is no market relationship between systems (fourth order strategies). By definition, control is inversely proportional to risk. Therefore, risk was estimated for each BATS based on the level of control exerted over its lifecycle by decision makers involved with Building170.

Reliability was also an important complementary consideration for determining how effective the BATS would be over time in achieving its desired impact without additional special efforts on the part of facility decision makers. In general, transparent solutions (where users are unaware that a better product has been substituted for another, for instance) are more reliable than other solutions. Transparent technology-based solutions are more reliable than solutions dependent on consistent *behavior* of stakeholders. For example, installing a technology that separates waste has a greater reliability than if stakeholders are expected to remember over the long term to separate their own wastes. Provided adequate expertise exists to operate and maintain the technologies, technology-based solutions avoid the foibles of reliance on human behavior for their success.

The third evaluation criterion was value, in this case referring to the ability of each BATS to achieve the goal of eliminating impacts without causing other impacts as a result. BATS were rated based on how much of the undesirable impact they would eliminate if implemented correctly, and how many new undesirable impacts their implementation would generate.

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[11] Although collecting information about cash flow constraints during the building life cycle was part of the data collection efforts of this project, no such information was available to enable determination of feasibility based on the cash flow requirements of implementing BATS. Moreover, the stakeholders specifically directed the researchers to avoid using cost as a basis for eliminating options. Therefore, no BATS were eliminated based on life cycle cash flow requirements or first costs.

Table 2.1: Stakeholder Satisfaction Criteria

OBJECTIVE	DESCRIPTION
Environmental Performance	
Sustainability	The project should meet as many of the constraints for ideal sustainability as possible
Environmental showcase	The project should use technologies that can be successfully used in future Army projects, i.e., those which demonstrate the benefits and practicality of green technologies[12]
Demonstration of environmental building principles	The project should incorporate technologies and building practices in a way that meets sustainability constraints, and these practices should be documented and presented as part of the building itself
Historic Preservation	
Use of historic space	The project should make use of a presently abandoned historical building
Preservation of exterior appearance	Modifications to the building should preserve its exterior appearance to preserve historical integrity
Strengthening of historic district	The project should integrate with its context in a way that strengthens the overall integrity and vitality of the district and post
Demonstration of methods for sustainable use of historic space	The project should incorporate as many components of the existing facility as possible that do not violate sustainability constraints
Building Performance	
Services	The building should provide services for its occupants such as on-site food preparation facilities, bicycle racks and showers, seating away from work areas, and adequate provision for electrical loads
Indoor environment	The building should provide for superior indoor environment conditions for its occupants, including adequate lighting with maximal daylighting, thermal comfort, air quality, and acoustic control
Space allocation	The building should provide the maximum amount of space possible to each occupant without violating Army regulations for space allocation
Privacy	Spaces within the building should provide adequate privacy for all occupants to accomplish their work objectives without distraction or compromising security
Appearance	The building should meet historic preservation requirements and make use of technologies that have a good appearance, in order to meet the demonstration functions of the building
Educational ability	The building should incorporate methods and technologies (signage, sensors/monitors, etc.) that enable users and visitors to learn more about the technologies and strategies incorporated
Project Performance	
Cost	The project design should not be constrained by cost, but should seek to optimize the life cycle cost of the resulting building
Schedule	The project should be able to be completed within a reasonable amount of time, or as quickly as possible

[12] One participant in a group interview stated that the project should "demonstrate that green doesn't have to be uncomfortable". Another stated that the project should show that "sustainable technologies don't have to be outrageous".

The last criterion, difficulty, was included as a measure of how able project stakeholders are to implement the solution, given the available resources, current objectives and expectations, and constraints associated with this specific project situation and context. Solutions were rated as more difficult to implement if they required additional resources (including time, cost, expertise, etc.), or changes in current behavior for affected stakeholders.

Table 2.2: Project Feasibility Constraints

CONSTRAINT	DESCRIPTION
Army Regulations	
Space allocation	The space allocated to each function should not exceed Army space allocation requirements
Contractor selection/hiring	The project must be completed with contractors that meet Army contracting requirements, which in this case means 8-A firms
Environmental regulations	The project should not violate any applicable Executive Orders or other environmental regulations
Historic preservation regulations	The project should conform to all Army historic preservation requirements
Historic Preservation	
SHPO requirements	The project should meet all requirements of the State Historic Preservation Office
DOI requirements	The project should meet all requirements of the U.S. Department of the Interior for historic preservation
Applicable Building Codes & Standards	
Energy	The project should meet all applicable energy codes, including the state commercial building codes and any referenced standards such as ASHRAE 90.1
Life Safety	The project should meet all applicable life safety codes and structural integrity requirements
ADA	The project should provide access for disabled people in conformance with Americans with Disabilities Act requirements
Project Delivery Constraints	
Budget	No specific cap has been established, but a discrete number of approximately $3 million has been submitted as part of a DD1391 request for capital funds
Schedule	No specific schedule has been established

Table 2.3 lists the ratings and associated criteria for each of the four factors used to evaluate potential BATS. Together, the four criteria return a qualitative comparison of the relative costs and benefits of each option. Appendix E to this report contains ratings of each feasible solution based on these two criteria, which served as the basis for prioritizing recommendations. Chapter 3 of this report discusses outcome of the ratings, contained in the form of recommendations for Building 170. BATS were prioritized by sorting according to highest ratings in the four categories. Easiest difficulty BATS were ranked highest, followed by BATS with highest value, and BATS with highest reliability and risk.

Table 2.3: Criteria for Rating BATS

RATING	CRITERIA
RISK	
A	Classification as a First-order Strategy
B	Classification as a Second-order Strategy
C	Classification as a Third-order Strategy
D	Classification as a Fourth-order Strategy
RELIABILITY	
A	Excellent – completely transparent technologies requiring no behavioral changes on the part of stakeholders and resulting in no perceptible changes in performance
B	Good – transparent technologies that require no behavioral changes on the part of building users, but may require behavioral changes on the part of building professionals (e.g., designers, contractors, operators, maintainers, etc.)
C	Fair – non-transparent technologies that produce noticeable changes in performance and require some adaptation or "getting used to" by users
D	Poor – strategies relying mostly or completely on behavioral modification of users
VALUE	
A	Excellent – will completely eliminate undesirable impact without creating any significant new undesirable impacts that can't be easily addressed
B	Good – will partially eliminate undesirable impact without creating any significant new undesirable impacts that can't be easily addressed
C	Fair – will completely eliminate undesirable impact, but at the same time will create new undesirable impacts that cannot be easily addressed
D	Poor – will partially eliminate undesirable impact, but at the same time will create new undesirable impacts that cannot be easily addressed
DIFFICULTY	
A	Easy – requires no additional resources AND no significant behavior changes.
B	Doable – requires some additional resources OR some change in behavior or expectations on the part of stakeholders
C	Difficult – requires many additional resources OR significant change in behavior or expectations of stakeholders
D	Impossible – some policy or constraint prohibits implementation, or BATS is unavailable in this situation. Change in policy would be required for implementation.

2.6 Development of Research Agenda for New BATS

After reviewing the pool of existing sustainable facility BATS, some sustainability improvement opportunities existed for which there were no BATS that could reduce negative resource base and ecosystem impacts to zero while maintaining stakeholder satisfaction. For these opportunities, functional descriptions were developed to describe performance requirements for new technologies and strategies that should be developed to fill these gaps. These performance requirements were expressed as performance-based specifications for research and development of new technologies and strategies that are needed to achieve true sustainability for built facilities. Each specification was expressed in the following form:

- Achieve <outcome or functional benefit for humans>…
- …without compromising <functional benefits provided by linked systems>…
- …with zero impacts in terms of <specific impacts caused by present system>…
- …and without causing other negative impacts in linked systems.

Together, these performance-based specifications comprised a research agenda for the development of new sustainable facilities technologies and strategies that can improve the sustainability of future Army facilities. This research agenda was a primary outcome of this project. Specific research needs are included as part of the next chapter, which presents the results and recommendations that came out of the method described in this chapter.

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3.0 Results and Recommendations

The original objectives of this project were described in Chapter 1 of this report. They were:

1) To determine if any improvements can be made to the recommendations prepared by the working groups of the charrette for retrofit of Building 170

2) To identify existing best available technologies and strategies that could be implemented to improve the sustainability performance of the proposed retrofit

3) To delineate areas where research and development is needed to provide new technologies and strategies to improve sustainability performance

4) To compare the outcomes of LEED-based solution development with systems-based solution development

This chapter describes the results of systems-based sustainability assessment that achieve these objectives.

3.1 Opportunities for Improving the Proposed Retrofit State of Building 170

The Southface team that developed the proposed retrofit state of Building 170 considered most of the major options for creating a sustainable facility within the scope of the study they chose. With few exceptions, their recommendations made use of Best Available Technologies and Strategies in the categories of impacts they considered in their study. However, the systems-based model identified two main types of impacts that keep the proposed retrofit state of Building 170 from being truly sustainable:

- Unavoidable impacts of any facility project, such as the impacts associated with manufacturing products and transporting them to the project site, or the impacts associated with disposal of waste, even if that disposal involves recycling

- Unconsidered impacts from categories that the team did not explicitly consider, such as most of the impacts associated with ongoing operations and maintenance of the facility

Within these categories, the kinds of impacts not addressed in previous studies include:

- Impacts due to import of new products to the system, arising from the inevitable manufacture and transport impacts of those products

- Impacts due to unavoidable export of waste from the site, including transport, recovery, and storage

- Impacts from fugitive or unintended emissions, i.e., from a "leaky system"

- Impacts associated with importing potable water that originates outside the system

- Impacts associated with large-scale wastewater treatment using current best practices

- Impacts of landscape disturbance

- Impacts associated with electrical power generation using current practices

These unaddressed impacts represent opportunities to improve the sustainability of the proposed retrofit state. The recommendations of BATS generated in this study specifically address these unaddressed impacts.

3.2 Recommendations of BATS for Sustainability Improvement

The process described in Chapter 2 generated potential BATS in four categories: Construction Inputs, Construction Outputs, Operations & Maintenance Inputs, and Operations & Maintenance Outputs. As described earlier, the complete set of BATS are listed in Appendix D and rated in Appendix E. The resulting prioritization of BATS is shown in Tables 3.1 – 3.4 for each of the four categories, with highest ranking BATS listed first. In these tables, similar BATS for specific impacts have been collapsed into one line item. The complete listing of all BATS associated with each impact chain is provided in Appendices D and E.

3.3 Needed Research and Development of New BATS

The systems-based sustainability assessment process used in this process is beneficial in that it provides a systematic method for identifying areas in which new research and development (R&D) are needed to fill gaps in the current base of technologies and strategies for creating sustainable buildings. In this study, the scope of analysis for generating R&D recommendations was limited to impacts identified in the context of this specific project. This set of recommendations is not necessarily comprehensive, since there may be additional needs in different contexts or for different types of buildings. R&D recommendations, expressed in the form of performance specifications, are presented here in terms of the seven categories of impacts identified as significant in this project. These impacts, listed in Section 3.1 of the report, comprise the challenges that must be addressed to create a truly sustainable building and are discussed in turn in the following subsections.

3.3.1 Import of New Products into the System

The first category of impacts is associated with the import of new products into the system as part of construction, operations, and maintenance. Since construction is defined as creating something new, by definition these impacts are unavoidable for any kind of physical construction process. Nonetheless, significant opportunities exist for reducing the impacts associated with manufacturing and transport of products or offsetting their negative impacts. Specific research needs in this area include:

- Transportation technologies or strategies that achieve the requirement of getting products *to* and *from* the site with zero impacts in terms of energy consumption and air pollution, and without causing other negative impacts avoided by current transportation methods.
- Manufacturing methods that achieve the requirements of *producing* required building products with zero impacts to resource bases or ecosystems, and without causing other negative impacts currently avoided by existing manufacturing processes.
- Building technologies that do not require manufacture (e.g., that can be reused from other projects or restored in existing buildings), that achieve the required levels of building performance as required to achieve stakeholder satisfaction, with zero impacts to resource bases or ecosystems and without causing other negative impacts currently avoided by existing building technologies.
- Building technologies that do not require transport (e.g., that can be developed sustainably from resources available on a typical site), that achieve the required levels of building performance as required to achieve stakeholder satisfaction, with zero impacts to resource bases or ecosystems and without causing other negative impacts currently avoided by existing building technologies.

Table 3.1: Prioritized BATS for Minimizing the Impacts of Construction Inputs

BEST AVAILABLE TECHNOLOGIES AND STRATEGIES
1. Reuse FF&E from occupants' present office space
2. Keep existing plumbing system in place
3. Keep all existing landscape and site features in place; do not modify
4. Keep second-floor breezeway to permit access to all building areas
5. Keep existing windows and doors in place; supplement as needed
6. Keep existing finishes in place; supplement as needed
7. Keep existing FF&E in place; supplement as needed
8. Repair existing elevator; do not replace
9. Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)
10. Take action to avoid equivalent amounts of energy by other systems (energy offsets)
11. Use products generated close to site
12. Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components
13. Keep existing HVAC in place; supplement as needed
14. Keep existing electrical system components in place and supplement as needed
15. Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods
16. Use elevator with high efficiency drive system
17. Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms
18. Reuse products from other buildings (e.g., doors and interior windows)
19. Reduce user expectations for thermal comfort; require wear of appropriate clothing and do not modify building envelope
20. Reduce user expectations for interior finishes and do not modify existing finishes
21. Reduce user expectations for FF&E and do not modify existing finishes
22. Reduce user expectations for HVAC and do not modify existing system
23. Reduce user requirements for power and do not modify existing system
24. Use sustainably harvested lumber for all wood products (doors and windows)
25. Use completely recycled content envelope products (e.g., cellulose, steel for doors/window frames, roofing products)

Table 3.2: BATS for Minimizing the Impacts of Construction Outputs

BEST AVAILABLE TECHNOLOGIES AND STRATEGIES
1. Do not modify existing landscape, to reduce dust generation
2. Recover corresponding amounts of materials from other projects and divert for reuse or recycling
3. Take action to avoid equivalent amounts of energy by other systems (energy offsets)
4. Divert other wastewater streams besides stormwater to new wetlands-based treatment systems created by modifying post sed ponds
5. Prevent an equivalent amount of wastewater on other projects via the use of water-saving technologies
6. Avoid the use of heavy equipment during construction to avoid landscape disturbance
7. Stage all equipment, storage, and dumpsters on paved (rather than vegetated) areas to avoid disturbance
8. Preserve an equivalent amount of landscape/ecosystem/vegetation on another project
9. Donate or give away all masonry units, furnishings, lighting fixtures, and wood for reuse
10. Avoid as much demolition as possible
11. Use manual separation to avoid impacts of associated equipment
12. Reuse as much material on site as possible (e.g., concrete/masonry rubble, cabinets as furnishings, etc.)
13. Avoid as much construction as possible
14. Reuse as much material on site as possible (e.g., sheetrock or cardboard packaging as soil amendments)
15. Minimize use of water on site during construction
16. Use sedimentation fencing, mulch, or other methods to immediately protect disturbed areas
17. Reduce user expectations for “instant landscaping” and plant more, less-developed plants rather than fewer well-developed ones
18. Use only native plantings to avoid the need for chemical fertilizers, pesticides, or irrigation
19. Avoid the use of annual plants; use perennials in all applications
20. Plant additional vegetation or restore local ecosystems to improve their ability to assimilate fugitive emissions
21. Repair any damage done to site ecosystems using ecosystem restoration/decontamination methods
22. Treat all wastewater on site using living machines or other technologies
23. Require all recyclers to reuse, then recycle, as much material as possible, using renewable energy and sustainable methods
24. Require transport of all materials using sustainably-fueled vehicles or other sustainable mechanisms
25. Require all product suppliers to take back all packaging, or minimize its use, or use reusable/recyclable/recycled packaging
26. Encourage Atlanta POTW to improve efficiency/sustainability of its treatment systems
27. Avoid the use of any product that could contaminate the site soil, landscape, or groundwater during construction. Divert all wastes to appropriate receptacles
28. Eliminate all fugitive emissions during construction using dust suppression/containment systems
29. Encourage City of Atlanta POTW to use land application of sludge instead of landfilling
30. Apply dust suppression systems at other projects to reduce corresponding amounts of fugitive emissions
31. Apply strategies at other locations to reduce urban heat island effects (e.g., high albedo roofing, preservation of landscape, ecosystem restoration)

Table 3.3: BATS for Minimizing the Impacts of Operations & Maintenance Inputs

BEST AVAILABLE TECHNOLOGIES AND STRATEGIES
1. Keep existing finishes in place; supplement as needed
2. Keep existing FF&E in place; supplement as needed
3. Audit all office practices to minimize the need for general office supplies
4. Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)
5. Take action to avoid equivalent amounts of energy by other systems (energy offsets)
6. Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components
7. Use products generated close to site
8. Use only toilet paper from recycled or sustainably harvested sources
9. Use only trash can liners made from recycled plastic or from corn starch or other renewable materials
10. Use only bio-based soaps that do not require use of nonrenewable resources
11. Use lamps made from recycled materials
12. Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods
13. Purchase products only from manufacturers that demonstrate sustainable manufacturing processes
14. Use products with maximal post-consumer recycled content or from sustainably harvested sources
15. Justify the need for all office equipment
16. Plant vegetation and restore ecosystems to improve the ability of the natural environment to assimilate air pollution
17. Prevent an equivalent amount of air pollution by reducing emissions from other sources
18. Work with City of Atlanta/East Point to promote water conservation
19. Do not use trash can liners except in receptacles for food waste or compostable waste
20. Avoid the use of specialized cleaners
21. Use only water-based or bio-based cleaning products
22. Purchase in large containers and transfer as needed to small containers that are reused
23. Maintain all equipment and finishes using appropriate practices to avoid the need for excess maintenance products
24. Regularly inspect all systems to avoid the need for significant repairs
25. Reduce user expectations for thermal control and downsize mechanical systems
26. Do not irrigate landscape
27. Do not use liquid hand soap; use bar soap instead
28. Turn off equipment not being used
29. Eliminate the need for providing drinking water by requiring all users to provide their own water
30. Restrict users from printing/copying; require electronic distribution of documents
31. Require users to provide their own food service supplies (e.g., plates, cups, silverware, napkins, etc.)
32. Use GOOS (Good on one Side) paper for all draft documents and notes
33. Take action to avoid equivalent amounts of energy consumption by other systems (energy offsets), e.g., installing energy efficient lighting, HVAC, etc. in other buildings
34. Prevent the consumption of an equivalent amount of potable water by installing water-efficient appliances or repairing line leaks in other projects
35. Use LED lighting or CFL lighting that last longer and require less frequent bulb replacement
36. Use on-demand hot water heaters to minimize energy wasted due to unnecessary hot water reserves
37. Use LED egress lighting to permanently light all corridors
38. Use reusable plates, cups, silverware, and other food service supplies rather than disposable ones
39. Reduce user expectations for interior finishes and do not modify existing finishes

BEST AVAILABLE TECHNOLOGIES AND STRATEGIES
40. Reduce user expectations for FF&E and do not modify existing finishes
41. Require users to provide their own towels for drying hands; do not supply disposable towels
42. Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms
43. Work with GA Power to promote energy conservation and load balancing efforts among their customer base, in order to increase the efficiency/sustainability of their overall generation system
44. Minimize the need for water by using mechanical rather than chemical cleaning wherever possible
45. Work with City of Atlanta/East Point to reduce distribution losses via leak repair
46. Use only water-based or bio-based lubricants and sealants when practical
47. Reduce user expectations for hot water and eliminate hot water heating system
48. Reduce user expectations for plug power
49. Eliminate the need for water imports by installing enough storage to meet all needs using collected rainwater
50. Eliminate the need for off-site electrical power by using on-site renewable generation (e.g., photovoltaics) for all electrical loads
51. Eliminate the need for water for waste conveyance by using only waterless urinals and composting/incinerating toilets
52. Replace all power-using equipment (e.g., computers, copiers, etc.) with high efficiency models that have standby modes
53. Optimize building envelope, mechanical systems, lighting systems, and other power loads using best available technologies
54. Replace selected electric equipment with natural gas or biofuel equipment (e.g., hot water heaters, heating systems)
55. Work with GA Power to convert existing plants to more sustainable or efficient options
56. Work with GA Power to ensure installation of best available technologies for emissions controls
57. Recycle wastewater on site to displace potable water imports, e.g., by using graywater for toilet flushing, and on-site treated water for all nonpotable uses
58. Use alternatives to paper-based operations, including electronic presentations, electronic whiteboards, etc.
59. Require utility suppliers to provide green power generation from renewable sources

Table 3.4: BATS for Minimizing the Impacts of Operations & Maintenance Outputs

BEST AVAILABLE TECHNOLOGIES AND STRATEGIES
1. Do not modify existing landscape
2. Stage all equipment, storage, and dumpsters on paved (rather than vegetated) areas to avoid disturbance
3. Eliminate all fugitive emissions by avoiding landscape disturbance
4. Audit all office practices to minimize the need for general office supplies (and subsequent waste generation)
5. Recover corresponding amounts of materials from other projects and divert for reuse or recycling
6. Take action to avoid equivalent amounts of energy by other systems (energy offsets)
7. Divert other wastewater streams besides stormwater to new wetlands-based treatment systems created by modifying post sed ponds
8. Prevent the generation of an equivalent amount of wastewater on other projects via the use of water-saving technologies
9. Avoid the use of heavy equipment during operations/maintenance to avoid landscape disturbance
10. Preserve an equivalent amount of landscape/ecosystem/vegetation on another project
11. Use products with maximal post-consumer recycled content or from sustainably harvested sources
12. Plant additional vegetation or restore local ecosystems to improve their ability to assimilate fugitive emissions
13. Donate or give away any waste products that could be reused
14. Use only products whose packaging can be composted on site
15. Use sedimentation fencing, mulch, or other methods to immediately protect disturbed areas
16. Avoid the use of any product that could contaminate the site soil, landscape, or groundwater during operations/maintenance. Divert all wastes to appropriate receptacles
17. Use only organic products for landscape maintenance
18. Use only native plantings to avoid the need for chemical fertilizers, pesticides, or irrigation
19. Avoid the use of annual plants; use perennials in all applications
20. Restrict users from printing/copying; require electronic distribution of documents
21. Use manual separation to avoid impacts of associated equipment
22. Reuse as much material on site as possible (e.g., GOOS paper, disposable silverware, etc.)
23. Use GOOS (Good on one Side) paper for all draft documents and notes
24. Repair any damage done to site ecosystems using ecosystem restoration/decontamination methods
25. Use durable rather than disposable products
26. Treat all wastewater on site using living machines or other technologies
27. Require all recyclers to reuse, then recycle, as much material as possible, using renewable energy and sustainable methods
28. Require transport of all materials using sustainably-fueled vehicles or other sustainable mechanisms
29. Encourage Atlanta POTW to improve efficiency/sustainability of its treatment systems
30. Use manual methods wherever possible for landscape maintenance (e.g., rakes instead of leaf blowers)
31. Use integrated pest management
32. Minimize or eliminate external site lighting
33. Use only products that come with no or minimal packaging
34. Require users to empty their own waste receptacles
35. Encourage City of Atlanta POTW to use land application of sludge instead of landfilling
36. Apply strategies at other locations to reduce urban heat island effects (e.g., high albedo roofing, preservation of landscape, ecosystem restoration)
37. Use alternatives to paper-based operations, including electronic presentations, electronic whiteboards, etc.
38. Minimize generation of wastewater by using waterless or ultra-conserving fixtures such as waterless urinals or composting/incinerating toilets

3.3.2 Impacts of Unavoidable Export of Waste

The second category of impacts is associated with the export of matter and energy not needed by the system as part of construction, operations, and maintenance. If, as discussed in the previous impact area, materials and products must be imported into the system to achieve construction, operations, and maintenance goals, then certain amounts of materials will have to be exported from the system in order to prevent accumulation of materials in the system. For example, *something* has to happen to the waste generated by users in their operation of the building; otherwise, it would continue to pile up inside the system and eventually overwhelm available storage capacity. Nonetheless, significant opportunities exist for reducing the impacts associated with recovery, separation, transport, and/or storage impacts of waste or offsetting those negative impacts. Specific research needs in this area include:

- Transportation technologies or strategies that achieve the requirement of getting products *to* and *from* the site with zero impacts in terms of energy consumption and air pollution, and without causing other negative impacts avoided by current transportation methods.
- Separation and recovery technologies that achieve the requirements of maximizing the reusability or recyclability of waste with zero impacts to resource bases or ecosystems, and without causing other negative impacts currently avoided by existing disposal processes.
- Building technologies that do not require extraneous packaging or maintenance using additional matter or energy, that achieve the required levels of building performance as required to achieve stakeholder satisfaction, with zero impacts to resource bases or ecosystems and without causing other negative impacts currently avoided by existing building technologies.
- Packaging technologies that can be used for other purposes on site after they have served their initial purpose, that achieve the required levels of building performance as required to achieve stakeholder satisfaction, with zero impacts to resource bases or ecosystems and without causing other negative impacts currently avoided by existing building technologies.
- Equipment technologies for performing office functions (e.g., computers, printers, and other electronic storage and information dissemination technologies) that require no physical inputs of materials (like toner or paper) to achieve the required levels of function as required to achieve stakeholder satisfaction, with zero impacts to resource bases or ecosystems and without causing other negative impacts currently avoided by existing building technologies.

3.3.3 Impacts of Fugitive Emissions

The third category of impacts is associated with fugitive or unintended emissions that emerge from the system as a result of construction, operations, and maintenance, such as dust, air pollution, heat, and light. In some cases, the surrounding environment can easily assimilate fugitive emissions with little or no impact. However, in most cases of development in urban areas or where other projects are going on nearby, fugitive emissions can cause significant impacts over time in combination with the fugitive emissions from other projects. Specific research needs in this area include:

- Emissions avoidance strategies that result in building technologies which can achieve the requirements of construction, operations, and maintenance with zero impacts in terms of energy consumption and environmental pollution, and without causing other negative impacts avoided by current methods.
- Emissions containment technologies or strategies that enable the use of current building technologies and methods while preventing the export of fugitive emissions off site and dealing with them effectively on site, with zero impacts to resource bases and ecosystems, and without causing other negative impacts avoided by current methods.
- Emissions offset technologies or strategies that can reduce impacts of construction by making easy modifications to operating buildings, with zero impacts to resource bases and ecosystems, and without causing other negative impacts avoided by current methods.

3.3.4 Impacts of Importing Potable Water

The fourth category of impacts is associated with importing potable water to the facility system. In many cases, obtaining and treating water exclusively within the site boundaries is infeasible or would cause worse sustainability impacts than centralized water plants. Moreover, since massive distribution infrastructure is already in place in many locations, development of parallel capacity would be a waste of this existing resource. Opportunities exist in this area in terms of better centralized treatment systems, lower impact distributed treatment systems, and technologies that provide the functions presently performed by potable water without using water at all. Specific research needs in this area include:

- <u>Centralized water treatment systems</u> that achieve the requirement of purifying water to potable levels with zero impacts in terms of toxic chemicals and aquifer depletion, and without causing other negative impacts avoided by current treatment methods.
- <u>Lower impact distributed treatment systems</u> that enable the purification of water to potable levels on site, with zero impacts to ecosystems and resource bases and without causing other negative impacts avoided by current treatment methods.
- <u>Building technologies and strategies</u> that enable current levels of performance without requiring potable water at all (e.g., better composting toilets), without violating stakeholder satisfaction requirements, and without causing other negative impacts avoided by current building technologies and strategies.

3.3.5 Impacts of Exporting Wastewater

The fifth category of impacts is associated with the export of wastewater from the system. Typically, built facilities export all wastewater (including stormwater, blackwater, greywater, and potable water used for conveyance) from their site to centralized treatment plants. Technologies and strategies are needed to reduce the generation of wastewater by facility systems, to improve the impacts of centralized treatment, and to provide alternative methods of treatment on site. Specific research needs in this area include:

- <u>Building technologies and strategies</u> that reduce or eliminate the need for use of potable water for conveyance, with zero impacts to stakeholders, resource bases and ecosystems, and without causing other negative impacts avoided by current technologies.
- <u>Building technologies and strategies</u> that use nonpotable water to replace current uses of potable water (thereby reducing the total load of wastewater), with zero impacts to stakeholders, resource bases and ecosystems, and without causing other negative impacts avoided by current technologies.
- <u>Building technologies and strategies</u> that facilitate the infiltration, absorption, and treatment of stormwater on site, with zero impacts to stakeholders, resource bases and ecosystems, and without causing other negative impacts avoided by current technologies.
- <u>Centralized treatment technologies and strategies</u> that enable the purification of wastewater to safe levels, with zero impacts to resource bases and ecosystems and without causing other negative impacts avoided by current treatment methods.
- <u>Distributed wastewater treatment technologies and strategies</u> that enable the purification of wastewater to safe levels on site, with zero impacts to resource bases and ecosystems and without causing other negative impacts avoided by current treatment methods.

3.3.6 Impacts of Landscape Disturbance

The sixth category of impacts is associated with the disturbance of landscape and ecosystems as a byproduct of constructing, operating, and maintaining built facilities. Specific research needs in this area include:

- <u>Technologies or strategies for avoiding landscape disturbance</u> during construction, operations, and maintenance that achieve the requirement of providing an aesthetically pleasing site with zero impacts to resource bases and ecosystems, and without causing other negative impacts avoided by current technologies.
- <u>Technologies or strategies for repairing landscape disturbance</u> during construction, operations, and maintenance that achieve the requirement of providing an aesthetically pleasing site with zero impacts to resource bases and ecosystems, and without causing other negative impacts avoided by current technologies.
- <u>Technologies or strategies for construction operations</u> that meet construction requirements without damaging site ecosystems or landscapes, and without causing other negative impacts avoided by current technologies.

3.3.7 Impacts of Importing Electrical Power from Nonrenewable Sources

The last category of impacts is associated with the import of electrical energy into the facility over its life cycle from unsustainable sources. Opportunities in this category include the development of better centralized generation methods, more effective distributed generation methods, and technologies and equipment within the facility itself that require zero energy to achieve their functions. Specific research needs in this area include:

- Centralized generation strategies that achieve the requirement of energy production with zero impacts to ecosystems and resource bases, and without causing other negative impacts avoided by current generation methods.
- Distributed generation strategies that achieve the requirement of reliable electricity production to meet on site stakeholder needs, with zero impacts to ecosystems and resource bases, and without causing other negative impacts avoided by current generation methods.
- Building technologies and equipment that meet stakeholder functional requirements (e.g., for heating, air quality, lighting, and plug loads) with either zero use of electrical power, or within the generation capacities of small, renewable distributed systems, with zero impacts to ecosystems and resource bases, and without causing other negative impacts avoided by current generation methods.

3.4 Comparison of the LEED Approach with the Systems-based Approach

The final objective of this study was to compare the LEED-based approach to sustainability improvement with the systems-based approach demonstrated in this project. Table 3.5 lists some of the relevant pros and cons of each system in terms of its ability to achieve truly sustainable building projects.

While each approach has its strengths and weaknesses, one conclusion of this study is that it may be most effective to use the two methods in concert with one another rather than trying to optimize one or the other alone. The LEED-based method used in previous studies did a good job of identifying BATS that apply to this building situation, at least for the aspects of the facility it considered. If LEED had a more comprehensive coverage of the full spectrum of building impacts, it would serve as a template for applying BATS to building projects. LEED developers intend to regularly update the LEED system to incorporate new BATS as they develop, although designers will be dependent upon the rigor and regularity with which the system is updated.

Table 3.5: Comparison of LEED with Systems-based Sustainability Assessment

	LEED-BASED APPROACH	SYSTEMS-BASED APPROACH
Pros	• Widely accepted in the U.S. • Clearly defined goals that are understandable to practitioners • Well-understood methods for verifying performance	• Provides a systematic way to comprehensively identify and analyze all possible impacts of the project • Usable at different phases of project development to examine implications of different scenarios • Can identify gaps in the set of existing technologies and strategies where new BATS need to be developed
Cons	• Does not incorporate all impacts and therefore does not result in a truly sustainable building • Difficult to use in its entirety in doing quick performance testing of project scenarios • Has “blind spots” in areas not considered in the rating system	• Does not have the ability to automatically identify and consider the relationships between changes to one system and subsequent impacts in another • Data collection can be arduous • Often significant assumptions are required in early project phases before specific products and suppliers have been identified

In contrast, the systems-based sustainability assessment method is a more general method for identifying all the aspects of a built facility that need to be addressed in order to achieve sustainability. Accompanied by a current database of BATS for sustainable facilities, this method provides a good way to identify specific BATS from the database that can be used to achieve sustainability for a given project. It also has the flexibility to be applied to many different kinds of projects in many different contexts, unlike the LEED method which depends on the existence of BATS templates for different project types.

Used together, the methods can result in a more sustainable building than LEED alone. LEED plays the necessary function of quickly identifying the lowest hanging fruit for the project to which it is applied. Supplemented by the systems-based method to fill in the gaps, projects that approach the goal of true sustainability can result. The next chapter describes this and other conclusions that have come out of this study.

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4.0 Discussion and Conclusions

Prior to this study, the Army had no means of:

- Identifying how sustainable Building 170 will be as a result of implementing sustainability recommendations, and
- Documenting a generalizable process for identifying sustainability improvement options that will achieve sustainability goals for other building projects

In response to these needs, the Army Environmental Policy Institute commissioned this project to apply systems-based sustainability assessment as a means to comparatively evaluate different scenarios with respect to Building 170, and to document the application of the process to evaluate how well it might work in trying to increase the sustainability of other Army capital projects. There were two primary outcomes of this project, described in the previous chapters of this report:

- A set of recommendations related to Building 170 identifying ways in which the sustainability of the proposed retrofit can be improved through existing and yet-to-be-developed technologies and strategies
- Demonstration of the process of systems-based sustainability analysis as the foundation for the design and development of sustainable Army facilities.

This final chapter of the report discusses the significance and implications of the findings of this project, the applicability and benefits of the systems-based analysis method, questions raised by the study, and specific areas for future research that can improve the process of systems-based analysis in future applications.

4.1 Significance and Implications of Project Findings

The main findings of this project were associated with the ability of the systems-based assessment method to identify gaps in LEED-based sustainable design. The project found that, while LEED provides a straightforward and well-understood method for identifying sustainable best practices, it does not address all the possible impacts of a built facility that could affect its sustainability. Therefore, projects that use LEED as a design tool will indeed be more sustainable than their traditional counterparts, but they may not achieve the goal of true sustainability.

The Army is considering various tools and techniques for improving the sustainability of its capital facility stock. LEED has so far served as a significant starting point for a proposed Army rating tool, and other military and federal agencies are also using LEED and derivations for guidance in their projects. The significance of the findings of this report mean that LEED is a good starting point for sustainable design, but it should not be considered a tool for finding all of the possible impacts associated with a facility design. As a rating tool, it was not intended to serve this purpose. Accompanied with a tool such as the systems-based model that focuses on identifying and mitigating *all* impacts of the facility, the LEED tool can be very useful in creating more sustainable facilities. However, used alone, it will not necessarily result in a completely sustainable building. In fact, LEED focuses only on one specific type of facility (offices), and is in general less easily applied for retrofit or rehabilitation projects than for new construction. For projects outside these parameters, LEED may be less effective and result in a solution with more gaps in the quest for sustainability.

Additional findings of the project revealed that there are several kinds of unavoidable impacts of projects that may make achieving true sustainability virtually impossible using present methods. For example, there are impacts associated with the production and transportation of any kind of new product, and these must be completely eliminated or offset to have a truly sustainable facility. At this point in time, achieving true sustainability may be extremely arduous, although improvements to current practice can certainly be made.

For stakeholders of the Building 170 project, the findings of this report indicate that there are additional measures (some of them very easy) that can and should be implemented as part of the project to make it more sustainable. The previous chapter of the report describes these recommendations in detail, and prioritizes them according to the order in which they should be considered as solutions for the building. Building 170 stakeholders should also realize that it will be difficult or impossible to achieve true sustainability in this project, given the constraints, requirements, and expectations of stakeholders and the fundamental procedures and policies of the Army. Nonetheless, improvements can and should be made to the proposed retrofit design developed in previous studies.

For other Army facility decision makers and policy makers, this report should serve as an example of a potential tool in the arsenal of facility design and operations that can result in buildings better able to meet the needs of their stakeholders, with lower impacts over time and with ongoing benefits to the Army. Researchers and developers will also benefit from the research needs identified using the systems-based analysis method, since they will have a clear picture of what needs to be done to improve the state of the art in building technologies and strategies.

4.2 Applicability and Benefits of the Systems-based Analysis Method

This study had two fundamental goals, one specific, and one more general. First, the study was intended to find ways to improve the sustainability of the building being analyzed, Building 170 at Fort McPherson. A second goal, with much broader potential impacts, was to demonstrate the process of systems-based sustainability analysis as a tool for Army facility decision makers. The study achieved both of these goals.

The systems-based analysis method was able to identify additional sustainability improvement recommendations not found using the LEED-based design method. These recommendations, if implemented in the Building 170 project, will result in a more sustainable building than could have been constructed based on prior work. For other Army facilities, the method demonstrated here could be applied to analyze proposed conceptual designs to search for improvement options, or as a basis for guiding the design process itself. The process is generalizable to other facility types (unlike the LEED approach), and the same steps can be applied to analyze many different kinds of facilities. The primary challenge will be collection of data and/or development of appropriate assumptions in order to populate the model with enough data to draw conclusions. This challenge is discussed further in Section 4.4: Areas for Future Research.

4.3 Questions Raised by the Study

The primary question raised by this study is of whether it is ever possible to achieve a truly sustainable system in today's building context. In the case of Building 170, most impacts could be eliminated completely only by using offsets derived from improving other systems. In the larger picture, offsets will be an important strategy for achieving sustainability goals at reasonable costs after the lowest hanging fruits have been obtained for a given project. However, eventually the number of offset opportunities will be reduced, and we may ultimately have to change our whole attitude toward the use of natural resources and ecosystems. This shift in expectations will involve changing our requirements for stakeholder satisfaction.

Some strategies exist today that represent a start in this direction, although they are primarily behavioral in nature. For example, changes in user behavior such as wearing temperature-appropriate clothing can make a significant difference in the quantity of resources required for climate control, and subsequent impacts to ecosystems. However, as designers we are taught not to rely on the behavior of users for any potential benefits, and to account for a broad variety of behaviors in our designs. In the future, we will have to answer the question of how far we are willing to go before we elect to simply change our behavior. We will also need to develop better ways to estimate the risk and reliability of these solutions, since they can offer the greatest possible impact at lowest cost.

A final question generated in this study is the issue of how to incorporate adaptability into the design of the retrofit itself. While adaptability for future use was not specifically identified as a stakeholder goal during any of the data collection for this project and was therefore not explicitly included in the analysis, this quality is an important consideration for sustainability if the facility is to continue to be useful in the long term. The original designers of the facility likely did not consider that their facility would one day be converted into a modern office facility, and the construction of the building in many ways reflects that short-sightedness. With rapid advances in building technology such as telecommunication systems, controls, and finishes, there is a strong need to create a building that can be more easily modified and upgraded to accommodate new technologies that will be necessary to meet future functional requirements. How should adaptability be incorporated into the sustainable design process? Is it worthwhile to make compromises *now* in how many resources are consumed and how much waste is generated if future expenditures of resources can be saved? The consideration of future use of the facility beyond AEPI's requirements was outside the scope of this study, but it should definitely be addressed in future applications of the analysis methods to ensure that we as designers of a sustainable facility do not make the same short-sighted choices as did the designers of the original facility. Questions of the time value of resources and environmental impacts must also be addressed in order to compare the relative sustainability of impacts over time.

4.4 Areas for Future Research

In conclusion, this study identified several areas for future research associated with systems-based sustainability modeling in general. First, development of impact values associated with different technologies was a significant challenge addressed in this study by using ordinal values for comparing impacts. In the future, quantitative models of system impacts should be developed in order to provide better resolution for modeling different scenarios. At this conceptual stage of design, however, ordinal numbers were quite sufficient to identify potential impacts and develop general recommendations.

One area not explored in this demonstration was the possibility of one type of impact being used to offset another type of impact (e.g., using water savings to compensate for energy consumption). While this kind of amalgamation is theoretically possible, it requires a much better understanding of the interactions and overall status of our ecosystems and resource bases. However, if these kinds of compensating impacts can be used to improve building sustainability, then they may offer lower cost solutions for sustainability improvement than were generated in this study.

Merging the systems-based sustainability assessment tool with other tools for quantity take-offs, simulations, and design tools could significantly improve the time required to generate alternatives. Innovations are underway in many forums for developing a common syntax for building-related modeling tools, and as these solutions develop, such integration of tools into a single design suite may become possible. An additional area to be automated would be to develop models that automatically capture the interactions between the sub-systems that comprise buildings themselves. In implementation of the model in this situation, these interactions were captured based on the design knowledge of the modeler. However, significant progress could be made in improving the utility of the model for non-designers by building in basic relationships that describe how building sub-systems interact.

Finally, a major challenge in this study involved finding ways to articulate stakeholder satisfaction requirements and constraints. A variety of methods, ranging from surveys to individual interviews to group surveys were used to gain multiple perspectives on the requirements and constraints of this project. The methods tested in this study were quite time consuming and required significant effort to obtain and verify results. Future research should address the need for fast, cost-effective, and accurate methods to elicit stakeholder preferences and requirements.

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5.0 References

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Appendix A: System State Profiles

Legend:

† - Southface estimate

* - indicates flow not used in this scenario

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Systems Profile: Status Quo State

Input Flows - Construction

	Flow	Source	Quantity	Probable RBI: Energy	Water	Nonrenewables	Plants	Animals	Probable EI: Air Quality	Water Quality	Soil Quality	Flora Quality	Fauna Quality	Rating: RBI	EI	Comments
	Precipitation/Storm water															
	Water	Natural	+	0	+	+	+	+	+	+	0	+	+	+	+	45 inches/year
	Solar Radiation															
	Heat	Natural	+	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
	Light	Natural	+	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
	Electrical Power															
	Electricity	Grid- Fossil fuel generation	0	-	0	-	0	0	-	-	0	-	0	-	-	Unknown; assumed to be negligible
	Potable Water															
	Water	Chattahoochee/East Point	0	0	-	0	0	0	0	+	0	-	-	-	-	Unknown; assumed to be negligible
	Shell Construction															
*	Windows	Unknown manufacturer	0	-	0	-	-	0	0	0	0	-	0	-	-	Original windows kept; negligible replacement in this scenario
*	Doors	Unknown manufacturer	0	-	0	-	-	0	0	0	0	-	0	-	-	Original doors kept; negligible replacement in this scenario
	Roof - slate shingles	Unknown manufacturer	+	-	0	-	0	0	0	0	-	-	0	-	-	Replacement with similar slate shingles
*	Roof - recycled rubber	Unknown manufacturer	0	-	0	-	0	0	0	0	0	0	0	-	0	Not used in this scenario
*	Insulation - blown cellulose	Unknown manufacturer	0	-	0	-	-	0	0	0	0	-	0	-	-	Not used in this scenario
*	Insulation - thermal acoustic panels	Unknown manufacturer	0	-	0	-	0	0	0	0	-	0	0	-	-	Not used in this scenario
	Shell Repair	Unknown manufacturer	0	-	0	-	0	0	0	0	0	0	0	-	0	Negligible
	Interior Construction															
	Walls	Unknown manufacturer	+	-	0	-	-	0	0	0	0	-	0	-	-	Some existing walls replaced with frame construction
	Interior Windows	None	0	-	0	-	-	0	0	0	0	-	0	-	-	No windows added
	Interior Doors	None	0	-	0	-	-	0	0	0	0	-	0	-	-	No doors added
	Interior Finishes															
	Paint - standard	Unknown manufacturer	+	-	0	-	0	0	-	-	0	0	0	-	-	Repaint all painted surfaces (no change across scenarios)
*	Paint - Low VOC	Unknown manufacturer	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Carpet	Unknown manufacturer	+	-	-	-	0	0	-	-	0	0	0	-	-	Recarpet all floor areas
*	Carpet Tile	Unknown manufacturer	0	-	-	-	0	0	0	-	0	0	0	-	-	Not used in this scenario
	Tile	Unknown manufacturer	+	-	0	-	0	0	0	0	0	0	0	-	0	Missing tiles repaired/replaced
	Ceiling Systems	Unknown manufacturer	+	-	0	-	0	0	0	0	0	0	0	-	0	Ceiling tiles replaced/repaired as needed
	Trim	Unknown manufacturer	+	-	0	0	-	0	0	0	0	-	0	-	-	All trim repainted
	FF&E															
	Movable Partitions	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	New partitions added
	Other Furniture	Unknown manufacturer	+	-	0	-	-	0	0	0	0	-	0	-	-	All existing furniture replaced
*	Recycled solid surface countertops	Unknown manufacturer	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario

Systems Profile: Status Quo State

Input Flows - Construction

	Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
HVAC Construction																
	Piping	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
	Ductwork	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
	Chiller	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Kept in place (110 tons)
	Boiler	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Kept in place (district heating)
*	Geothermal system	Unknown manufacturer	0	-	0	-	0	0	-	0	0	-	-	-	-	Not used in this scenario
	Pumps	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Kept in place
*	Automated ventilation controls	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	IAQ sensors	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	VAV Air Handler	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
	Fans	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Kept in place
Electrical Construction																
	Wiring	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
	Conduit	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
*	Fuel cell generation system	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	Photovoltaic panels	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	Occupancy sensors	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	Photocells for outdoor lighting	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
	Lighting Fixtures	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
	Outlet Fixtures	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
*	AFV Refueling station	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
Plumbing Construction																
	Piping	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal; some replacement
	Sinks	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal; some replacement
	Toilets	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal; some replacement
*	Graywater piping and storage	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	Rainwater cistern	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	Rainwater catchment system	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	Outdoor micropool	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
	Sprinkler Fixtures	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
*	Geothermal desuperheater	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
	Hot Water Heaters	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Kept in place (standard efficiency)

Systems Profile: Status Quo State

Input Flows - Construction

	Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Site Construction																
	Standard sod	Unknown manufacturer	+	0	-	-	-	0	0	-	-	-	-	-	-	Complete removal and replacement
*	Native plantings	Unknown manufacturer	0	0	0	0	+	+	+	+	+	+	+	+	+	Not used in this scenario
	Bushes	Unknown manufacturer	+	0	-	-	-	0	0	-	-	-	-	-	-	Complete removal; some replacement
	Trees	Unknown manufacturer	0	0	-	0	-	0	+	-	-	0	0	-	-	No change
	Furnishings	Unknown manufacturer	+	-	0	-	-	0	-	0	0	-	0	-	-	Complete removal; some replacement
	Concrete	Unknown manufacturer	+	-	-	-	0	0	-	0	0	0	0	-	-	Repair to some existing pavement
*	Flyash concrete	Unknown manufacturer	0	-	-	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	Porous concrete	Unknown manufacturer	0	-	-	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	Grasspave pavement	Unknown manufacturer	0	-	0	-	0	0	+	+	+	0	0	-	+	Not used in this scenario
*	Rainwater apron	Unknown manufacturer	0	-	0	-	0	0	0	0	0	0	0	-	0	Not used in this scenario
*	Bicycle storage	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
*	Sheltered bus stop	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
Conveyance																
	Elevator	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	New elevator added using existing pit

Systems Profile: Status Quo State

Output Flows - Construction

	Flow	Sink	Quantity	Probable RBI: Energy	Water	Nonrenewables	Plants	Animals	Probable EI: Air Quality	Water Quality	Soil Quality	Flora Quality	Fauna Quality	Rating: RBI	EI	Comments
Fugitive Emissions																
	Heat	Ambient environment	+	0	0	0	-	-	-	0	0	-	-	-	-	Constant across scenarios
	Dust/Air Pollutants	Ambient environment	+	0	-	0	-	-	-	-	0	-	-	-	-	Increased due to site clearing
Demolition Waste																
	Wood	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	Landfilled
*	Wood	Chipped/recycled on post	0	-	0	0	+	0	-	-	+	+	0	-	-	Not used in this scenario
	Bathroom Fixtures	Land fill/salvage	+	0	0	0	0	0	0	-	-	0	0	0	-	Salvaged/landfilled
	Brick	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	Landfilled; includes demolition of interior walls
	Cabinets/Benches	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	Landfilled/salvaged
*	Cabinets/Benches	Salvage	0	0	0	0	0	0	0	0	0	0	0	0	0	Not used in this scenario
	Carpet	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	Landfilled
*	Carpet	Recycler	0	-	-	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Ceiling Tiles	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	Landfilled
*	Ceiling Tiles	Recycler	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Fluorescent Lamps	Universal waste handler	+	-	0	0	0	0	0	0	-	0	0	-	-	Handled as universal waste
*	Fluorescent Lamps	Recycler	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Metals	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	No ceiling grid replacement; landfill of remaining waste
*	Metals	Recycler	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Lighting Fixtures	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	Landfilled
*	Lighting Fixtures	Recycler	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Concrete	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	Landfilled
*	Concrete	Recycler	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Glass	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	Landfilled
*	Glass	Recycler	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Slate Shingles	Land fill	+	0	0	0	0	0	0	-	-	0	0	0	-	Landfilled
Construction Waste																
	Paper products	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled
*	Paper products	Recycler	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Landscaping/Compostable Waste	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled
	Metals	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled
*	Metals	Recycler	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Plastics	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled
	Wood	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled
*	Wood	Chipped/recycled on post	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Sheetrock	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled
*	Sheetrock	Chipped/recycled on post	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Other	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled

Systems Profile: Status Quo State

Output Flows - Construction

Flow	Sink	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Collected Wastewater															
Stormwater	Post sedimentation ponds	+	0	+	0	0	0	0	0	0	+	+	+	+	Collected in storm drains to post sed ponds
Sanitary Wastewater	City of Atlanta POTW	0	0	+	-	0	0	0	+	0	0	0	-	+	Negligible
Other Contaminants	City of Atlanta POTW	+	0	+	-	0	0	0	+	0	0	0	-	+	Typical
Sediment Runoff															
Topsoil	Post sedimentation ponds	+	0	+	0	0	0	0	-	0	+	+	+	-	Increased due to site clearing
Clay Sediment	Post sedimentation ponds	+	0	+	0	0	0	0	-	0	+	+	+	-	Increased due to site clearing
Other Contaminants	Post sedimentation ponds	+	0	+	0	0	0	0	-	0	+	+	+	-	Increased due to site clearing
Groundwater Infiltration															
Water	Aquifer	+	0	+	0	+	+	0	+	+	+	+	+	+	Some increase due to pavement removal
Sediment	Site landscape	+	0	0	0	-	0	0	-	-	0	0	-	-	Increased due to site clearing
Other Contaminants	Site landscape	+	0	0	0	-	0	0	-	-	0	0	-	-	Increased due to site clearing

Systems Profile: Status Quo State

Input Flows - Operations & Maintenance

	Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
	Precipitation/Stormwater															
	Water	Natural	+	0	+	+	+	+	+	+	0	+	+	+	+	45 inches/year†
	Solar Radiation															
	Heat	Natural	+	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
	Light	Natural	+	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
	Electrical Power															
	Electricity	Grid- Fossil fuel generation	+	-	0	-	0	0	-	-	0	-	0	-	-	2.1 Billion Btu/year†
	Potable Water															
	Water	Chattahoochee/East Point	+	0	-	0	0	0	0	+	0	-	-	-	-	442,000 gal/year†
	Interior Finishes															
	Paint - standard	Unknown manufacturer	+	-	0	-	0	0	-	-	0	0	0	-	-	5-10 year repaint cycle or as needed
*	Paint - Low VOC	Unknown manufacturer	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Carpet	Unknown manufacturer	+	-	-	-	0	0	-	-	0	0	0	-	-	5-10 year recarpet cycle or as needed
*	Recycled carpet tiles	Unknown manufacturer	0	-	-	-	0	0	0	-	0	0	0	-	-	Not used in this scenario
	Tile	Unknown manufacturer	0	-	0	-	0	0	0	0	0	0	0	-	0	Repair as needed - negligible
	Ceiling Systems	Unknown manufacturer	0	-	0	-	0	0	0	0	0	0	0	-	0	Repair as needed - negligible
*	Recycled ceiling panels	Unknown manufacturer	0	-	0	0	0	0	0	0	0	0	0	-	0	Not used in this scenario
	Trim	Unknown manufacturer	+	-	0	0	-	0	0	0	0	-	0	-	-	Repaint during repaint cycle
	Replacement FF&E															
	Movable Partitions	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Unknown replacement cycle
	Other Furniture	Unknown manufacturer	+	-	0	-	-	0	0	0	0	-	0	-	-	Unknown replacement cycle
	Commodities															
	Lamps	Unknown manufacturer	+	-	0	-	0	0	-	0	0	0	0	-	-	Replaced as needed
	Towels	Unknown manufacturer	+	-	-	0	-	0	-	-	0	-	0	-	-	Replaced as needed
	Hand Soap	Unknown manufacturer	+	-	0	-	0	0	0	-	0	0	0	-	-	Replaced as needed
	Toilet Paper	Unknown manufacturer	+	-	-	0	-	0	-	-	0	-	0	-	-	Replaced as needed
	Trash Can Liners	Unknown manufacturer	+	-	0	-	0	0	0	-	0	0	0	-	-	Replaced as needed
	Other	Unknown manufacturer	+	0	0	0	0	0	0	0	0	0	0	0	0	Replaced as needed
	Cleaning Products															
	General Purpose	Unknown manufacturer	+	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance
	Toilet Cleaners	Unknown manufacturer	+	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance
	Floor Cleaners	Unknown manufacturer	+	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance
	Carpet Cleaners	Unknown manufacturer	+	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance
	Glass Cleaners	Unknown manufacturer	+	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance

Systems Profile: Status Quo State

Input Flows - Operations & Maintenance

Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Maintenance Products															
Lubricants	Unknown manufacturer	+	-	0	-	0	0	0	-	0	0	0	-	-	Used for maintenance of mechanical systems
Sealants/Caulks	Unknown manufacturer	+	-	0	-	0	0	-	-	0	0	0	-	-	Replaced on a 15-20 year cycle or as needed
Refrigerants	Unknown manufacturer	+	-	0	0	0	0	-	0	0	0	0	-	-	Recharged annually or on typical maintenance cycle
Pesticides/Fertilizers	Unknown manufacturer	+	-	-	-	0	0	0	-	-	-	-	-	-	Used in typical maintenance
Asphalt Products	Unknown manufacturer	+	-	0	-	0	0	-	-	-	0	0	-	-	5 year reseal; 10-15 year replacement cycle
User Products															
Paper Products	Unknown manufacturer	+	-	-	0	-	0	-	-	0	-	0	-	-	Input by users as needed
Foods/Beverages	Unknown manufacturer	+	-	-	0	-	0	-	-	0	-	0	-	-	Input by users as needed
General Office Supplies	Unknown manufacturer	+	-	-	0	-	0	-	-	0	-	0	-	-	Input by users as needed
Toner/Printing Cartridges	Unknown manufacturer	+	-	0	-	0	0	-	-	0	0	0	-	-	Input by users as needed
Other	Unknown manufacturer	+	0	0	0	0	0	0	0	0	0	0	0	0	Input by users as needed

Systems Profile: Status Quo State

Output Flows - Operations & Maintenance

Flow	Sinks	Quantity	Probable RBI: Energy	Water	Nonrenewables	Plants	Animals	Probable EI: Air Quality	Water Quality	Soil Quality	Flora Quality	Fauna Quality	Rating: RBI	EI	Comments
Fugitive Emissions															
Heat	Ambient environment	+	0	0	0	-	-	-	0	0	-	-	-	-	Constant across scenarios
Light	Ambient environment	+	0	0	0	-	-	-	0	0	-	-	-	-	From site illumination fixtures
Particulates	Ambient environment	+	0	-	0	-	-	-	-	0	-	-	-	-	From soil accumulation on paved areas
Air Pollutants	Ambient environment	+	0	-	0	-	-	-	-	0	-	-	-	-	From cleaning products and ventilation systems
Solid Waste															
Paper	Post recycler	+	-	0	0	0	0	0	0	0	0	0	-	0	Limited recycling using post system
Cardboard	Post recycler	+	-	0	0	0	0	0	0	0	0	0	-	0	Limited recycling using post system
Plastics	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Land filled
Wood	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Land filled
Food Waste	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Land filled
Glass	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Land filled
Metals	Post recycler	+	-	0	0	0	0	0	0	0	0	0	-	0	Limited recycling using post system
Landscaping/Compostable Waste	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Land filled
Hazardous Wastes	Hazardous waste landfill	+	-	0	0	0	0	0	-	-	0	0	-	-	Special hazardous waste handling
Other	Land fill	+	-	0	0	0	0	0	-	-	0	0	-	-	Land filled
Collected Wastewater															
Stormwater	Post sedimentation ponds	+	0	+	0	0	0	0	0	0	+	+	+	+	Collected and conveyed to post sedimentation pond
Sanitary Wastewater	City of Atlanta POTW	+	0	+	-	0	0	0	+	0	0	0	-	+	Collected and conveyed to City of Atlanta POTW
Other Contaminants	City of Atlanta POTW	+	0	+	-	0	0	0	+	0	0	0	-	+	Collected and conveyed to post sedimentation pond
Groundwater Infiltration															
Water	Aquifer	+	0	+	0	+	+	0	+	+	+	+	+	+	From rainfall on lawn areas only
Sediment	Site landscape	+	0	0	0	-	0	0	-	-	0	0	-	-	From rainfall on lawn areas only
Other Contaminants	Site landscape	+	0	0	0	-	0	0	-	-	0	0	-	-	From rainfall on lawn areas only

Systems Profile: Proposed Retrofit State

Input Flows - Construction

Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Precipitation/Stormwater															
Water	Natural	Same	0	+	+	+	+	+	+	0	+	+	+	+	45 inches/year
Solar Radiation															
Heat	Natural	Same	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
Light	Natural	Same	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
Electrical Power															
Electricity	Grid- Fossil fuel generation	0	-	0	-	0	0	-	-	0	-	0	-	-	Unknown; assumed to be negligible
Potable Water															
Water	Chattahoochee/East Point	0	0	-	0	0	0	0	+	0	-	-	-	-	Unknown; assumed to be negligible
Shell Construction															
Windows	Unknown manufacturer	More	-	0	-	-	0	0	0	0	-	0	-	-	Original windows repaired and supplemented with new interiors
Doors	Unknown manufacturer	More	-	0	-	-	0	0	0	0	-	0	-	-	Original doors repaired and air sealed
Roof - slate shingles	Unknown manufacturer	0	-	0	-	0	0	0	0	-	-	0	-	-	Not used in this scenario
Roof - recycled rubber	Unknown manufacturer	More	-	0	-	0	0	0	0	0	0	0	-	0	All slate shingles replaced with slate-like recycled rubber shingles
Insulation - blown cellulose	Unknown manufacturer	More	-	0	-	-	0	0	0	0	-	0	-	-	Added in attic to achieve R-30 for roof
Insulation - thermal acoustic panels	Unknown manufacturer	More	-	0	-	0	0	0	0	-	0	0	-	-	Added to all exterior walls to add R-3 and acoustic privacy
Shell Repair	Unknown manufacturer	0	-	0	-	0	0	0	0	0	0	0	-	0	Negligible
Interior Construction															
Walls	Unknown manufacturer	0	-	0	-	-	0	0	0	0	-	0	-	-	All necessary existing walls kept in place
Interior Windows	None	0	-	0	-	-	0	0	0	0	-	0	-	-	All necessary existing windows kept in place
Interior Doors	None	0	-	0	-	-	0	0	0	0	-	0	-	-	All necessary existing doors kept in place
Interior Finishes															
Paint - standard	Unknown manufacturer	0	-	0	-	0	0	-	-	0	0	0	-	-	Not used in this scenario
Paint - Low VOC	Unknown manufacturer	More	-	0	0	0	0	0	0	0	0	0	-	0	All interior walls painted
Carpet	Unknown manufacturer	0	-	-	-	0	0	-	-	0	0	0	-	-	Not used in this scenario
Carpet Tile	Unknown manufacturer	More	-	-	-	0	0	0	-	0	0	0	-	-	Selected areas carpeted with recycled carpet tiles
Tile	Unknown manufacturer	Same	-	0	-	0	0	0	0	0	0	0	-	0	Missing tiles repaired/replaced
Ceiling Systems	Unknown manufacturer	0	-	0	-	0	0	0	0	0	0	0	-	0	Dropped ceilings removed and not replaced
Trim	Unknown manufacturer	Same	-	0	0	-	0	0	0	0	-	0	-	-	All trim repainted
FF&E															
Movable Partitions	Unknown manufacturer	Less	-	0	-	0	0	-	0	0	0	0	-	-	New partitions added
Other Furniture	Unknown manufacturer	Same	-	0	-	-	0	0	0	0	-	0	-	-	All existing furniture replaced
Recycled solid surface countertops	Unknown manufacturer	More	-	0	0	0	0	0	0	0	0	0	-	0	Added to replace any needed counter surfaces

Systems Profile: Proposed Retrofit State

Input Flows - Construction

Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
HVAC Construction															
Piping	Unknown manufacturer	Same	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
Ductwork	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Due to separate ventilation system
Chiller	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
Boiler	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
Geothermal system	Unknown manufacturer	More	-	0	-	0	0	-	0	0	-	-	-	-	Used to replace existing chillers/boilers
Pumps	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Replaced as part of geothermal system
Automated ventilation controls	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added to control ventilation system
IAQ sensors	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added to control ventilation system
VAV Air Handler	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added to allow use of ventilation only during swing seasons
Fans	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Replaced as part of geothermal system
Electrical Construction															
Wiring	Unknown manufacturer	Same	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
Conduit	Unknown manufacturer	Same	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
Fuel cell generation system	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
Photovoltaic panels	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
Occupancy sensors	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
Photocells for outdoor lighting	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
Lighting Fixtures	Unknown manufacturer	Less	-	0	-	0	0	-	0	0	0	0	-	-	Selected fixtures kept in place; majority of lighting replaced
Outlet Fixtures	Unknown manufacturer	Same	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
AFV Refueling station	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Not used in this scenario
Plumbing Construction															
Piping	Unknown manufacturer	Same	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal; some replacement
Sinks	Unknown manufacturer	Same	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal; some replacement
Toilets	Unknown manufacturer	Same	-	0	-	0	0	-	0	0	0	0	-	-	Replacement with extremely low flow fixtures (similar impacts)
Graywater piping and storage	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added to supply water for landscaping
Rainwater cistern	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added to supply water for landscaping (6,000 gallon capacity)
Rainwater catchment system	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added to supply water for landscaping
Outdoor micropool	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added for aesthetics and on-site treatment
Sprinkler Fixtures	Unknown manufacturer	Same	-	0	-	0	0	-	0	0	0	0	-	-	Complete removal and replacement
Geothermal desuperheater	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added to replace traditional tank hot water heater
Hot Water Heaters	Unknown manufacturer	0	-	0	-	0	0	-	0	0	0	0	-	-	Replaced with geothermal desuperheater

Systems Profile: Proposed Retrofit State

Input Flows - Construction

Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Site Construction															
Standard sod	Unknown manufacturer	Less	0	-	-	-	0	0	-	-	-	-	-	-	Selected removal; no replacement
Native plantings	Unknown manufacturer	More	0	0	0	+	+	+	+	+	+	+	+	+	Replaces sod and some paved areas
Shrubbery	Unknown manufacturer	More	0	-	-	-	0	0	-	-	-	-	-	-	All shrubs preserved or relocated, and additional native shrubs added
Trees	Unknown manufacturer	More	0	-	0	-	0	+	-	-	0	0	-	-	Additional trees added (approximately 40)
Furnishings	Unknown manufacturer	More	-	0	-	-	0	-	0	0	-	0	-	-	Replacement with furnishings made from recycled materials
Concrete	Unknown manufacturer	0	-	-	-	0	0	-	0	0	0	0	-	-	Additional handicap access ramps added (approximately 12,000 sf)
Flyash concrete	Unknown manufacturer	More	-	-	-	0	0	-	0	0	0	0	-	-	Used to provide handicap access ramps (approximately 12,000 sf)
Porous concrete	Unknown manufacturer	More	-	-	-	0	0	-	0	0	0	0	-	-	Used to replace existing concrete in selected parking areas
Grasspave pavement	Unknown manufacturer	More	-	0	-	0	0	+	+	+	0	0	-	+	Used to replace existing pavement in firelanes (approx. 1,000 sf)
Rainwater apron	Unknown manufacturer	More	-	0	-	0	0	0	0	0	0	0	-	0	Added to deflect rainwater around building perimeter
Bicycle storage	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added to provide secure storage for bicycles
Sheltered bus stop	Unknown manufacturer	More	-	0	-	0	0	-	0	0	0	0	-	-	Added to encourage use of post shuttle/transit
Conveyance															
Elevator	Unknown manufacturer	Same	-	0	-	0	0	-	0	0	0	0	-	-	New elevator added using existing pit

Systems Profile: Proposed Retrofit State

Output Flows - Construction

Flow	Sink	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Fugitive Emissions															
Heat	Ambient environment	Less	0	0	0	-	-	-	0	0	-	-	-	-	Decreased due to preserving vegetation during construction
Dust/Air Pollutants	Ambient environment	Less	0	-	0	-	-	-	-	0	-	-	-	-	Decreased due to preserving vegetation during construction
Demolition Waste															
Wood	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	Not used in this scenario
Wood	Chipped/recycled on post	More	-	0	0	+	0	-	-	+	+	0	-	-	Most wood recycled or chipped for use in post landscaping
Bathroom Fixtures	Landfill/salvage	Less	0	0	0	0	0	0	-	-	0	0	0	-	Some sink fixtures left in place
Brick	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	All brick kept on site; total is less due to keeping interior walls in tact
Cabinets/Benches	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	Not used in this scenario
Cabinets/Benches	Salvage	More	0	0	0	0	0	0	0	0	0	0	0	0	All cabinets not kept intact are salvaged
Carpet	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	Not used in this scenario
Carpet	Recycler	More	-	-	0	0	0	0	0	0	0	0	-	0	All carpet recycled (if not contaminated)
Ceiling Tiles	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	Not used in this scenario
Ceiling Tiles	Recycler	More	-	0	0	0	0	0	0	0	0	0	-	0	All ceiling tiles recycled (if not contaminated)
Fluorescent Lamps	Universal waste handler	0	-	0	0	0	0	0	0	-	0	0	-	-	Not used in this scenario
Fluorescent Lamps	Recycler	More	-	0	0	0	0	0	0	0	0	0	-	0	All lamps collected and taken to a certified recycler
Metals	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	Not used in this scenario
Metals	Recycler	More	-	0	0	0	0	0	0	0	0	0	-	0	Ceiling grid and other metals collected and recycled
Lighting Fixtures	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	Not used in this scenario
Lighting Fixtures	Recycler	More	-	0	0	0	0	0	0	0	0	0	-	0	Any removed fixtures are recycled/salvaged
Concrete	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	Not used in this scenario
Concrete	Recycler	More	-	0	0	0	0	0	0	0	0	0	-	0	Brick and concrete reused/recycled (approximately 975 tons saved)
Glass	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	Not used in this scenario
Glass	Recycler	More	-	0	0	0	0	0	0	0	0	0	-	0	All glass recycled
Slate Shingles	Landfill	0	0	0	0	0	0	0	-	-	0	0	0	-	Used on site as part of landscaping
Construction Waste															
Paper products	Landfill	0	-	0	0	0	0	0	-	-	0	0	-	-	Not used in this scenario
Paper products	Recycler	More	-	0	0	0	0	0	0	0	0	0	-	0	All paper waste separated and collected for recycling
Landscaping/Compostable Waste	Landfill	0	-	0	0	0	0	0	-	-	0	0	-	-	Landscaping waste composted or reused on site
Metals	Landfill	0	-	0	0	0	0	0	-	-	0	0	-	-	Not used in this scenario
Metals	Recycler	More	-	0	0	0	0	0	0	0	0	0	-	0	All metals collected and recycled
Plastics	Landfill	Same	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled due to lack of recycling options
Wood	Landfill	0	-	0	0	0	0	0	-	-	0	0	-	-	Not used in this scenario
Wood	Chipped/recycled on post	More	-	0	0	0	0	0	0	0	0	0	-	0	All wood chipped and reused for landscaping on post
Sheetrock	Landfill	Less	-	0	0	0	0	0	-	-	0	0	-	-	Not used in this scenario
Sheetrock	Chipped/recycled on post	More	-	0	0	0	0	0	0	0	0	0	-	0	All sheetrock chipped and reused for soil amendments on post
Other	Landfill	Same	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled
Collected Wastewater															
Stormwater	Post sedimentation ponds	Less	0	+	0	0	0	0	0	0	+	+	+	+	Less runoff due to preserved vegetation
Sanitary Wastewater	City of Atlanta POTW	0	0	+	-	0	0	0	+	0	0	0	-	+	Negligible
Other Contaminants	City of Atlanta POTW	Same	0	+	-	0	0	0	+	0	0	0	-	+	Typical

Systems Profile: Proposed Retrofit State

Output Flows - Construction

Flow	Sink	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Sediment Runoff															
Topsoil	Post sedimentation ponds	Less	0	+	0	0	0	0	-	0	+	+	+	-	Less runoff due to preserved vegetation
Clay Sediment	Post sedimentation ponds	Less	0	+	0	0	0	0	-	0	+	+	+	-	Less runoff due to preserved vegetation
Other Contaminants	Post sedimentation ponds	Less	0	+	0	0	0	0	-	0	+	+	+	-	Less runoff due to preserved vegetation
Groundwater Infiltration															
Water	Aquifer	More	0	+	0	+	+	0	+	+	+	+	+	+	Some increase due to pavement removal
Sediment	Site landscape	Less	0	0	0	-	0	0	-	-	0	0	-	-	Less sedimentation due to preserved vegetation
Other Contaminants	Site landscape	Less	0	0	0	-	0	0	-	-	0	0	-	-	Less sedimentation due to preserved vegetation

Systems Profile: Proposed Retrofit State

Input Flows - Operations & Maintenance

Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Precipitation/Stormwater															
Water	Natural	Same	0	+	+	+	+	+	+	0	+	+	+	+	45 inches/year†
Solar Radiation															
Heat	Natural	Same	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
Light	Natural	Same	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
Electrical Power															
Electricity	Grid- Fossil fuel generation	Less	-	0	-	0	0	-	-	0	-	0	-	-	976 million Btu/year†
Potable Water															
Water	Chattahoochee/East Point	Less	0	-	0	0	0	0	+	0	-	-	-	-	310,000 gal/year†
Interior Finishes															
Paint - standard	Unknown manufacturer	0	-	0	-	0	0	-	-	0	0	0	-	-	Not used in this scenario
Paint - Low VOC	Unknown manufacturer	More	-	0	0	0	0	0	0	0	0	0	-	0	5-10 year repaint cycle or as needed
Carpet	Unknown manufacturer	0	-	-	-	0	0	-	-	0	0	0	-	-	Not used in this scenario
Recycled carpet tiles	Unknown manufacturer	More	-	-	-	0	0	0	-	0	0	0	-	-	5-10 year recarpet cycle with replacement/cleaning as needed
Tile	Unknown manufacturer	Same	-	0	-	0	0	0	0	0	0	0	-	0	Repair as needed - negligible
Ceiling Systems	Unknown manufacturer	0	-	0	-	0	0	0	0	0	0	0	-	0	Repair as needed - negligible
Recycled ceiling panels	Unknown manufacturer	0	-	0	0	0	0	0	0	0	0	0	-	0	Repair/replace as needed - negligible
Trim	Unknown manufacturer	Same	-	0	0	-	0	0	0	0	-	0	-	-	Repaint during repaint cycle
Replacement FF&E															
Movable Partitions	Unknown manufacturer	Less	-	0	-	0	0	-	0	0	0	0	-	-	Unknown replacement cycle
Other Furniture	Unknown manufacturer	Less	-	0	-	-	0	0	0	0	-	0	-	-	Unknown replacement cycle
Commodities															
Lamps	Unknown manufacturer	Less	-	0	-	0	0	-	0	0	0	0	-	-	Replaced as needed - longer lasting lamps (LEDs and CFs)
Towels	Unknown manufacturer	Same	-	-	0	-	0	-	-	0	-	0	-	-	Replaced as needed (not addressed in scenario)
Hand Soap	Unknown manufacturer	Same	-	0	-	0	0	0	-	0	0	0	-	-	Replaced as needed (not addressed in scenario)
Toilet Paper	Unknown manufacturer	Same	-	-	0	-	0	-	-	0	-	0	-	-	Replaced as needed (not addressed in scenario)
Trash Can Liners	Unknown manufacturer	Same	-	0	-	0	0	0	-	0	0	0	-	-	Replaced as needed (not addressed in scenario)
Other	Unknown manufacturer	Same	0	0	0	0	0	0	0	0	0	0	0	0	Replaced as needed (not addressed in scenario)
Cleaning Products															
General Purpose	Unknown manufacturer	Same	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance (not addressed in scenario)
Toilet Cleaners	Unknown manufacturer	Same	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance (not addressed in scenario)
Floor Cleaners	Unknown manufacturer	Same	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance (not addressed in scenario)
Carpet Cleaners	Unknown manufacturer	Same	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance (not addressed in scenario)
Glass Cleaners	Unknown manufacturer	Same	-	0	-	0	0	0	-	0	0	0	-	-	Used in typical maintenance (not addressed in scenario)

Systems Profile: Proposed Retrofit State

Input Flows - Operations & Maintenance

Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Maintenance Products															
Lubricants	Unknown manufacturer	Same	-	0	-	0	0	0	-	0	0	0	-	-	Used for maintenance of mechanical systems
Sealants/Caulks	Unknown manufacturer	More	-	0	-	0	0	-	-	0	0	0	-	-	Replaced on a 15-20 year cycle or as needed
Refrigerants	Unknown manufacturer	Less	-	0	0	0	0	-	0	0	0	0	-	-	Recharged annually or on typical maintenance cycle
Pesticides/Fertilizers	Unknown manufacturer	0	-	-	-	0	0	0	-	-	-	-	-	-	No pesticides/fertilizers used due to native plantings
Asphalt Products	Unknown manufacturer	Less	-	0	-	0	0	-	-	-	0	0	-	-	Much of asphalt replaced with alternative paving products
User Products															
Paper Products	Unknown manufacturer	Same	-	-	0	-	0	-	-	0	-	0	-	-	Input by users as needed (not addressed in scenario)
Foods/Beverages	Unknown manufacturer	Same	-	-	0	-	0	-	-	0	-	0	-	-	Input by users as needed (not addressed in scenario)
General Office Supplies	Unknown manufacturer	Same	-	-	0	-	0	-	-	0	-	0	-	-	Input by users as needed (not addressed in scenario)
Toner/Printing Cartridges	Unknown manufacturer	Same	-	0	-	0	0	-	-	0	0	0	-	-	Input by users as needed (not addressed in scenario)
Other	Unknown manufacturer	Same	0	0	0	0	0	0	0	0	0	0	0	0	Input by users as needed (not addressed in scenario)

Systems Profile: Proposed Retrofit State

Output Flows - Operations & Maintenance

Flow	Sinks	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Fugitive Emissions															
Heat	Ambient environment	Same	0	0	0	-	-	-	0	0	-	-	-	-	Constant across scenarios
Light	Ambient environment	Less	0	0	0	-	-	-	0	0	-	-	-	-	From site illumination fixtures - reduced in quantity
Particulates	Ambient environment	Less	0	-	0	-	-	-	-	0	-	-	-	-	Reduced due to preserving existing vegetation
Air Pollutants	Ambient environment	Same	0	-	0	-	-	-	-	0	-	-	-	-	From cleaning products and ventilation systems
Solid Waste															
Paper	Post recycler	Same	-	0	0	0	0	0	0	0	0	0	-	0	Limited recycling using post system
Cardboard	Post recycler	Same	-	0	0	0	0	0	0	0	0	0	-	0	Limited recycling using post system
Plastics	Landfill	Same	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled (not addressed in scenario)
Wood	Landfill	Same	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled (not addressed in scenario)
Food Waste	Landfill	Same	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled (not addressed in scenario)
Glass	Landfill	Same	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled (not addressed in scenario)
Metals	Post recycler	Same	-	0	0	0	0	0	0	0	0	0	-	0	Limited recycling using post system
Landscaping/Compostable Waste	Landfill	Same	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled (not addressed in scenario)
Hazardous Wastes	Hazardous waste landfill	Same	-	0	0	0	0	0	-	-	0	0	-	-	Special hazardous waste handling
Other	Landfill	Same	-	0	0	0	0	0	-	-	0	0	-	-	Landfilled (not addressed in scenario)
Collected Wastewater															
Stormwater	Post sedimentation ponds	Less	0	+	0	0	0	0	0	0	+	+	+	+	Captured as part of micropool system
Sanitary Wastewater	City of Atlanta POTW	Less	0	+	-	0	0	0	+	0	0	0	-	+	Captured as part of graywater system
Other Contaminants	City of Atlanta POTW	Less	0	+	-	0	0	0	+	0	0	0	-	+	Treated as part of micropool and less due to no fertilizers/pesticides
Groundwater Infiltration															
Water	Aquifer	More	0	+	0	+	+	0	+	+	+	+	+	+	Percolated through porous paving systems
Sediment	Site landscape	Less	0	0	0	-	0	0	-	-	0	0	-	-	Reduced due to preservation of existing vegetation
Other Contaminants	Site landscape	Less	0	0	0	-	0	0	-	-	0	0	-	-	Reduced due to no fertilizers/pesticides

Systems Profile: Ideal Sustainability State

Input Flows - Construction

	Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Precipitation/Stormwater																
	Water	Natural	+	0	+	+	+	+	+	+	0	+	+	+	+	45 inches/year
Solar Radiation																
	Heat	Natural	+	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
	Light	Natural	+	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
Electrical Power																
	Electricity	To be determined												0	0	
Potable Water																
	Water	To be determined												0	0	
Shell Construction																
*	Windows	To be determined												0	0	
*	Doors	To be determined												0	0	
	Roof - slate shingles	To be determined												0	0	
*	Roof - recycled rubber	To be determined												0	0	
*	Insulation - blown cellulose	To be determined												0	0	
*	Insulation - thermal acoustic panels	To be determined												0	0	
	Shell Repair	To be determined												0	0	Negligible
Interior Construction																
	Walls	To be determined												0	0	
	Interior Windows	To be determined												0	0	
	Interior Doors	To be determined												0	0	
Interior Finishes																
	Paint - standard	To be determined												0	0	
*	Paint - Low VOC	To be determined												0	0	
	Carpet	To be determined												0	0	
*	Carpet Tile	To be determined												0	0	
	Tile	To be determined												0	0	
	Ceiling Systems	To be determined												0	0	
	Trim	To be determined												0	0	
FF&E																
	Movable Partitions	To be determined												0	0	
	Other Furniture	To be determined												0	0	
*	Recycled solid surface countertops	To be determined												0	0	

Systems Profile: Ideal Sustainability State

Input Flows - Construction

	Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
HVAC Construction																
	Piping	To be determined												0	0	
	Ductwork	To be determined												0	0	
	Chiller	To be determined												0	0	
	Boiler	To be determined												0	0	
*	Geothermal system	To be determined												0	0	
	Pumps	To be determined												0	0	
*	Automated ventilation controls	To be determined												0	0	
*	IAQ sensors	To be determined												0	0	
*	VAV Air Handler	To be determined												0	0	
	Fans	To be determined												0	0	
Electrical Construction																
	Wiring	To be determined												0	0	
	Conduit	To be determined												0	0	
*	Fuel cell generation system	To be determined												0	0	
*	Photovoltaic panels	To be determined												0	0	
*	Occupancy sensors	To be determined												0	0	
*	Photocells for outdoor lighting	To be determined												0	0	
	Lighting Fixtures	To be determined												0	0	
	Outlet Fixtures	To be determined												0	0	
*	AFV Refueling station	To be determined												0	0	
Plumbing Construction																
	Piping	To be determined												0	0	
	Sinks	To be determined												0	0	
	Toilets	To be determined												0	0	
*	Graywater piping and storage	To be determined												0	0	
*	Rainwater cistern	To be determined												0	0	
*	Rainwater catchment system	To be determined												0	0	
*	Outdoor micropool	To be determined												0	0	
	Sprinkler Fixtures	To be determined												0	0	
*	Geothermal desuperheater	To be determined												0	0	
	Hot Water Heaters	To be determined												0	0	

Systems Profile: Ideal Sustainability State

Input Flows - Construction

	Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Site Construction																
	Standard sod	To be determined												0	0	
*	Native plantings	To be determined												0	0	
	Bushes	To be determined												0	0	
	Trees	To be determined												0	0	
	Furnishings	To be determined												0	0	
	Concrete	To be determined												0	0	
*	Flyash concrete	To be determined												0	0	
*	Porous concrete	To be determined												0	0	
*	Grasspave pavement	To be determined												0	0	
*	Rainwater apron	To be determined												0	0	
*	Bicycle storage	To be determined												0	0	
*	Sheltered bus stop	To be determined												0	0	
Conveyance																
	Elevator	To be determined												0	0	

Systems Profile: Ideal Sustainability State

Output Flows - Construction

	Flow	Sink	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Fugitive Emissions																
	Heat	Ambient environment												0	0	Constant across scenarios
	Dust / Air Pollutants	Ambient environment												0	0	
Demolition Waste																
	Wood	To be determined												0	0	
*	Wood	To be determined												0	0	
	Bathroom Fixtures	To be determined												0	0	
	Brick	To be determined												0	0	
	Cabinets / Benches	To be determined												0	0	
*	Cabinets / Benches	To be determined												0	0	
	Carpet	To be determined												0	0	
*	Carpet	To be determined												0	0	
	Ceiling Tiles	To be determined												0	0	
*	Ceiling Tiles	To be determined												0	0	
	Fluorescent Lamps	To be determined												0	0	
*	Fluorescent Lamps	To be determined												0	0	
	Metals	To be determined												0	0	
*	Metals	To be determined												0	0	
	Lighting Fixtures	To be determined												0	0	
*	Lighting Fixtures	To be determined												0	0	
	Concrete	To be determined												0	0	
*	Concrete	To be determined												0	0	
	Glass	To be determined												0	0	
*	Glass	To be determined												0	0	
	Slate Shingles	To be determined												0	0	
Construction Waste																
	Paper products	To be determined												0	0	
*	Paper products	To be determined												0	0	
	Landscaping / Compostable Waste	To be determined												0	0	
	Metals	To be determined												0	0	
*	Metals	To be determined												0	0	
	Plastics	To be determined												0	0	
	Wood	To be determined												0	0	
*	Wood	To be determined												0	0	
	Sheetrock	To be determined												0	0	
*	Sheetrock	To be determined												0	0	
	Other	To be determined												0	0	

Systems Profile: Ideal Sustainability State

Output Flows - Construction

Flow	Sink	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Collected Wastewater															
Stormwater	To be determined												0	0	
Sanitary Wastewater	To be determined												0	0	Negligible
Other Contaminants	To be determined												0	0	
Sediment Runoff															
Topsoil	To be determined												0	0	
Clay Sediment	To be determined												0	0	
Other Contaminants	To be determined												0	0	
Groundwater Infiltration															
Water	To be determined												0	0	
Sediment	To be determined												0	0	
Other Contaminants	To be determined												0	0	

Systems Profile: Ideal Sustainability State

Input Flows - Operations & Maintenance

	Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
	Precipitation/Stormwater															
	Water	Natural	+	0	+	+	+	+	+	+	0	+	+	+	+	45 inches/year†
	Solar Radiation															
	Heat	Natural	+	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
	Light	Natural	+	+	0	0	+	+	0	0	0	+	+	+	+	Constant across scenarios
	Electrical Power															
	Electricity	To be determined												0	0	
	Potable Water															
	Water	To be determined												0	0	
	Interior Finishes															
	Paint - standard	To be determined												0	0	
*	Paint - Low VOC	To be determined												0	0	
	Carpet	To be determined												0	0	
*	Recycled carpet tiles	To be determined												0	0	
	Tile	To be determined												0	0	
	Ceiling Systems	To be determined												0	0	
*	Recycled ceiling panels	To be determined												0	0	
	Trim	To be determined												0	0	
	Replacement FF&E															
	Movable Partitions	To be determined												0	0	
	Other Furniture	To be determined												0	0	
	Commodities															
	Lamps	To be determined												0	0	
	Towels	To be determined												0	0	
	Hand Soap	To be determined												0	0	
	Toilet Paper	To be determined												0	0	
	Trash Can Liners	To be determined												0	0	
	Other	To be determined												0	0	
	Cleaning Products															
	General Purpose	To be determined												0	0	
	Toilet Cleaners	To be determined												0	0	
	Floor Cleaners	To be determined												0	0	
	Carpet Cleaners	To be determined												0	0	
	Glass Cleaners	To be determined												0	0	

Systems Profile: Ideal Sustainability State

Input Flows - Operations & Maintenance

Flow	Source	Quantity	Probable RBI: Energy	Probable RBI: Water	Probable RBI: Nonrenewables	Probable RBI: Plants	Probable RBI: Animals	Probable EI: Air Quality	Probable EI: Water Quality	Probable EI: Soil Quality	Probable EI: Flora Quality	Probable EI: Fauna Quality	Rating: RBI	Rating: EI	Comments
Maintenance Products															
Lubricants	To be determined												0	0	
Sealants/Caulks	To be determined												0	0	
Refrigerants	To be determined												0	0	
Pesticides/Fertilizers	To be determined												0	0	
Asphalt Products	To be determined												0	0	
User Products															
Paper Products	To be determined												0	0	
Foods/Beverages	To be determined												0	0	
General Office Supplies	To be determined												0	0	
Toner/Printing Cartridges	To be determined												0	0	
Other	To be determined												0	0	

Systems Profile: Ideal Sustainability State

Output Flows - Operations & Maintenance

Flow	Sinks	Quantity	Probable RBI					Probable EI					Rating		Comments
			Energy	Water	Nonrenewables	Plants	Animals	Air Quality	Water Quality	Soil Quality	Flora Quality	Fauna Quality	RBI	EI	
Fugitive Emissions															
Heat	Ambient environment												0	0	Constant across scenarios
Light	Ambient environment												0	0	
Particulates	Ambient environment												0	0	
Air Pollutants	Ambient environment												0	0	
Solid Waste															
Paper	To be determined												0	0	
Cardboard	To be determined												0	0	
Plastics	To be determined												0	0	
Wood	To be determined												0	0	
Food Waste	To be determined												0	0	
Glass	To be determined												0	0	
Metals	To be determined												0	0	
Landscaping/Compostable Waste	To be determined												0	0	
Hazardous Wastes	To be determined												0	0	
Other	To be determined												0	0	
Collected Wastewater															
Stormwater	To be determined												0	0	
Sanitary Wastewater	To be determined												0	0	
Other Contaminants	To be determined												0	0	
Groundwater Infiltration															
Water	To be determined												0	0	
Sediment	To be determined												0	0	
Other Contaminants	To be determined												0	0	

Appendix B: Profile Comparisons and Gap Analysis

Note: Values are ordinal only; interval scaling is not implied.

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Input Flows - Construction													
		Impact		Status Quo			Proposed Retrofit			Ideal	Improvements?	
Flow	Source	RBI	EI	Qty	RBI	EI	Qty	RBI	EI	Rating	RBI	EI
Precipitation/Stormwater												
Water	Natural	+	+	+	Sustainable	Sustainable	Same	Sustainable	Sustainable	0	NO	NO
Solar Radiation												
Heat	Natural	+	+	+	Sustainable	Sustainable	Same	Sustainable	Sustainable	0	NO	NO
Light	Natural	+	+	+	Sustainable	Sustainable	Same	Sustainable	Sustainable	0	NO	NO
Electrical Power												
Electricity	Grid- Fossil fuel generation	-	-	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Potable Water												
Water	Chattahoochee/East Point	-	-	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Shell Construction												
Windows	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Doors	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Roof - slate shingles	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Roof - recycled rubber	Unknown manufacturer	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Insulation - blown cellulose	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Insulation - thermal acoustic panels	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Shell Repair	Unknown manufacturer	-	0	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Interior Construction												
Walls	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Interior Windows	None	-	-	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Interior Doors	None	-	-	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Interior Finishes												
Paint - standard	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Paint - Low VOC	Unknown manufacturer	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Carpet	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Carpet Tile	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Tile	Unknown manufacturer	-	0	+	Unsustainable	Neutral	Same	Unsustainable	Unsustainable	0	YES	YES
Ceiling Systems	Unknown manufacturer	-	0	+	Unsustainable	Neutral	0	Neutral	Neutral	0	NO	NO
Trim	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
FF&E												
Movable Partitions	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Other Furniture	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Recycled solid surface countertops	Unknown manufacturer	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO

Input Flows - Construction												
		Impact			Status Quo			Proposed Retrofit		Ideal	Improvements?	
Flow	Source	RBI	EI	Qty	RBI	EI	Qty	RBI	EI	Rating	RBI	EI
HVAC Construction												
Piping	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Ductwork	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	More	More Unsustainable	More Unsustainable	0	YES	YES
Chiller	Unknown manufacturer	-	-	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Boiler	Unknown manufacturer	-	-	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Geothermal system	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Pumps	Unknown manufacturer	-	-	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Automated ventilation controls	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
IAQ sensors	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
VAV Air Handler	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Fans	Unknown manufacturer	-	-	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Electrical Construction												
Wiring	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Conduit	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Fuel cell generation system	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Photovoltaic panels	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Occupancy sensors	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Photocells for outdoor lighting	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Lighting Fixtures	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Outlet Fixtures	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
AFV Refueling station	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Plumbing Construction												
Piping	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Sinks	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Toilets	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Graywater piping and storage	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Rainwater cistern	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Rainwater catchment system	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Outdoor micropool	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Sprinkler Fixtures	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Geothermal desuperheater	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Hot Water Heaters	Unknown manufacturer	-	-	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Site Construction												
Standard sod	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Native plantings	Unknown manufacturer	+	+	0	Neutral	Neutral	More	More Sustainable	More Sustainable	0	NO	NO
Shrubbery	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	More	More Unsustainable	More Unsustainable	0	YES	YES
Trees	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Furnishings	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	More	More Unsustainable	More Unsustainable	0	YES	YES
Concrete	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Flyash concrete	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Porous concrete	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Grasspave pavement	Unknown manufacturer	-	+	0	Neutral	Neutral	More	More Unsustainable	More Sustainable	0	YES	NO
Rainwater apron	Unknown manufacturer	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Bicycle storage	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Sheltered bus stop	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Conveyance												
Elevator	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES

Output Flows - Construction												
		Impact			Status Quo			Proposed Retrofit		Ideal	Improvements?	
Flow	Sink	RBI	EI	Qty	RBI	EI	Qty	RBI	EI	Rating	RBI	EI
Fugitive Emissions												
Heat	Ambient environment	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Dust/Air Pollutants	Ambient environment	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Demolition Waste												
Wood	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Wood	Chipped/recycled on post	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Bathroom Fixtures	Landfill/salvage	0	-	+	Neutral	Unsustainable	Less	Neutral	Less Unsustainable	0	NO	YES
Brick	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Cabinets/Benches	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Cabinets/Benches	Salvage	0	0	0	Neutral	Neutral	More	Neutral	Neutral	0	NO	NO
Carpet	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Carpet	Recycler	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Ceiling Tiles	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Ceiling Tiles	Recycler	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Fluorescent Lamps	Universal waste handler	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Fluorescent Lamps	Recycler	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Metals	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Metals	Recycler	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Lighting Fixtures	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Lighting Fixtures	Recycler	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Concrete	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Concrete	Recycler	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Glass	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Glass	Recycler	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Slate Shingles	Landfill	0	-	+	Neutral	Unsustainable	0	Neutral	Neutral	0	NO	NO
Construction Waste												
Paper products	Landfill	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Paper products	Recycler	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Landscaping/Compostable Waste	Landfill	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Metals	Landfill	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Metals	Recycler	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Plastics	Landfill	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Wood	Landfill	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Wood	Chipped/recycled on post	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Sheetrock	Landfill	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Sheetrock	Chipped/recycled on post	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Other	Landfill	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Collected Wastewater												
Stormwater	Post sedimentation ponds	+	+	+	Sustainable	Sustainable	Less	Less Sustainable	Less Sustainable	0	NO	NO
Sanitary Wastewater	City of Atlanta POTW	-	+	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Other Contaminants	City of Atlanta POTW	-	+	+	Unsustainable	Sustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Sediment Runoff												
Topsoil	Post sedimentation ponds	+	-	+	Sustainable	Unsustainable	Less	Less Sustainable	Less Unsustainable	0	NO	YES
Clay Sediment	Post sedimentation ponds	+	-	+	Sustainable	Unsustainable	Less	Less Sustainable	Less Unsustainable	0	NO	YES
Other Contaminants	Post sedimentation ponds	+	-	+	Sustainable	Unsustainable	Less	Less Sustainable	Less Unsustainable	0	NO	YES
Groundwater Infiltration												
Water	Aquifer	+	+	+	Sustainable	Sustainable	More	More Sustainable	More Sustainable	0	NO	NO
Sediment	Site landscape	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Other Contaminants	Site landscape	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES

Input Flows - Operations & Maintenance												
		Impact		Status Quo			Proposed Retrofit			Ideal	Improvements?	
Flow	Source	RBI	EI	Qty	RBI	EI	Qty	RBI	EI	Rating	RBI	EI
Precipitation/Stormwater												
Water	Natural	+	+	+	Sustainable	Sustainable	Same	Sustainable	Sustainable	0	NO	NO
Solar Radiation												
Heat	Natural	+	+	+	Sustainable	Sustainable	Same	Sustainable	Sustainable	0	NO	NO
Light	Natural	+	+	+	Sustainable	Sustainable	Same	Sustainable	Sustainable	0	NO	NO
Electrical Power												
Electricity	Grid- Fossil fuel generation	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Potable Water												
Water	Chattahoochee/East Point	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Interior Finishes												
Paint - standard	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Paint - Low VOC	Unknown manufacturer	-	0	0	Neutral	Neutral	More	More Unsustainable	Neutral	0	YES	NO
Carpet	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Recycled carpet tiles	Unknown manufacturer	-	-	0	Neutral	Neutral	More	More Unsustainable	More Unsustainable	0	YES	YES
Tile	Unknown manufacturer	-	0	0	Neutral	Neutral	Same	Neutral	Neutral	0	NO	NO
Ceiling Systems	Unknown manufacturer	-	0	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Recycled ceiling panels	Unknown manufacturer	-	0	0	Neutral	Neutral	0	Neutral	Neutral	0	NO	NO
Trim	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Replacement FF&E												
Movable Partitions	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Other Furniture	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Commodities												
Lamps	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Towels	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Hand Soap	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Toilet Paper	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Trash Can Liners	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Other	Unknown manufacturer	0	0	+	Neutral	Neutral	Same	Neutral	Neutral	0	NO	NO
Cleaning Products												
General Purpose	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Toilet Cleaners	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Floor Cleaners	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Carpet Cleaners	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Glass Cleaners	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Maintenance Products												
Lubricants	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Sealants/Caulks	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	More	More Unsustainable	More Unsustainable	0	YES	YES
Refrigerants	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Pesticides/Fertilizers	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	0	Neutral	Neutral	0	NO	NO
Asphalt Products	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
User Products												
Paper Products	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Foods/Beverages	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
General Office Supplies	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Toner/Printing Cartridges	Unknown manufacturer	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Other	Unknown manufacturer	0	0	+	Neutral	Neutral	Same	Neutral	Neutral	0	NO	NO

Output Flows - Operations & Maintenance

Flow	Sink	Impact RBI	Impact EI	Status Quo Qty	Status Quo RBI	Status Quo EI	Proposed Retrofit Qty	Proposed Retrofit RBI	Proposed Retrofit EI	Ideal Rating	Improvements? RBI	Improvements? EI
Fugitive Emissions												
Heat	Ambient environment	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Light	Ambient environment	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Particulates	Ambient environment	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Air Pollutants	Ambient environment	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Solid Waste												
Paper	Post recycler	-	0	+	Unsustainable	Neutral	Same	Unsustainable	Unsustainable	0	YES	YES
Cardboard	Post recycler	-	0	+	Unsustainable	Neutral	Same	Unsustainable	Unsustainable	0	YES	YES
Plastics	Landfill	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Wood	Landfill	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Food Waste	Landfill	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Glass	Landfill	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Metals	Post recycler	-	0	+	Unsustainable	Neutral	Same	Unsustainable	Unsustainable	0	YES	YES
Landscaping/Compostable Waste	Landfill	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Hazardous Wastes	Hazardous waste landfill	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Other	Landfill	-	-	+	Unsustainable	Unsustainable	Same	Unsustainable	Unsustainable	0	YES	YES
Collected Wastewater												
Stormwater	Post sedimentation ponds	+	+	+	Sustainable	Sustainable	Less	Less Sustainable	Less Sustainable	0	NO	NO
Sanitary Wastewater	City of Atlanta POTW	-	+	+	Unsustainable	Sustainable	Less	Less Unsustainable	Less Sustainable	0	YES	NO
Other Contaminants	City of Atlanta POTW	-	+	+	Unsustainable	Sustainable	Less	Less Unsustainable	Less Sustainable	0	YES	NO
Groundwater Infiltration												
Water	Aquifer	+	+	+	Sustainable	Sustainable	More	More Sustainable	More Sustainable	0	NO	NO
Sediment	Site landscape	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES
Other Contaminants	Site landscape	-	-	+	Unsustainable	Unsustainable	Less	Less Unsustainable	Less Unsustainable	0	YES	YES

Inputs - Construction		Unsustainable		Exactly Sustainable		Super-Sustainable			Unsustainable		Exactly Sustainable		Super-Sustainable	
Precipitation/Stormwater														
Water						S P							S P	
Solar Radiation														
Heat						S P							S P	
Light						S P							S P	
Electrical Power														
Electricity				S P							S P			
Potable Water														
Water				S P							S P			
Shell Construction														
Windows		P		S					P		S			
Doors		P		S					P		S			
Roof - slate shingles		S		P					S		P			
Roof - recycled rubber		P		S							S P			
Insulation - blown cellulose		P		S					P		S			
Insulation - thermal acoustic panels		P		S					P		S			
Shell Repair				S P							S P			
Interior Construction														
Walls		S		P					S		P			
Interior Windows				S P							S P			
Interior Doors				S P							S P			
Interior Finishes														
Paint - standard		S		P					S		P			
Paint - Low VOC		P		S							S P			
Carpet		S		P					S		P			
Carpet Tile		P		S					P		S			
Tile		S P							P		S			
Ceiling Systems		S		P							S P			
Trim		S P							S P					
FF&E														
Movable Partitions		S	P						S	P				
Other Furniture		S P							S P					
Recycled solid surface countertops		P		S							S P			
HVAC Construction														
Piping		S P							S P					
Ductwork	P	S						P	S					
Chiller				S P							S P			
Boiler				S P							S P			
Geothermal system		P		S					P		S			
Pumps				S P							S P			
Automated ventilation controls		P		S					P		S			
IAQ sensors		P		S					P		S			
VAV Air Handler		P		S					P		S			
Fans				S P							S P			

Note: Shaded items in the left column indicate sustainability improvement opportunities.

Inputs - Construction		Unsustainable		Exactly Sustainable		Super-Sustainable			Unsustainable		Exactly Sustainable		Super-Sustainable	
Electrical Construction														
Wiring		S P							S P					
Conduit		S P							S P					
Fuel cell generation system		P		S					P		S			
Photovoltaic panels		P		S					P		S			
Occupancy sensors		P		S					P		S			
Photocells for outdoor lighting		P		S					P		S			
Lighting Fixtures		S	P						S	P				
Outlet Fixtures		S P							S P					
AFV Refueling station		P		S					P		S			
Plumbing Construction														
Piping		S P							S P					
Sinks		S P							S P					
Toilets		S P							S P					
Graywater piping and storage		P		S					P		S			
Rainwater cistern		P		S					P		S			
Rainwater catchment system		P		S					P		S			
Outdoor micropool		P		S					P		S			
Sprinkler Fixtures		S P							S P					
Geothermal desuperheater		P		S					P		S			
Hot Water Heaters				S P							S P			
Site Construction														
Standard sod		S	P						S	P				
Native plantings				S		P					S		P	
Shrubbery	P	S						P	S					
Trees		P		S					P		S			
Furnishings		S P							S P					
Concrete		S		P					S		P			
Flyash concrete		P		S					P		S			
Porous concrete		P		S					P		S			
Grasspave pavement		P		S					P		S			
Rainwater apron		P		S							S P			
Bicycle storage		P		S					P		S			
Sheltered bus stop		P		S					P		S			
Conveyance														
Elevator		S P							S P					

Note: Shaded items in the left column indicate sustainability improvement opportunities.

Outputs - Construction		Unsustainable		Exactly Sustainable		Super-Sustainable			Unsustainable		Exactly Sustainable		Super-Sustainable	
Fugitive Emissions														
Heat		S	P						S	P				
Dust/Air Pollutants		S	P						S	P				
Demolition Waste														
Wood				S P					S		P			
Wood		P		S					P		S			
Bathroom Fixtures				S P					S	P				
Brick				S P					S		P			
Cabinets/Benches				S P					S		P			
Cabinets/Benches				S P							S P			
Carpet				S P					S		P			
Carpet		P		S							S P			
Ceiling Tiles				S P					S		P			
Ceiling Tiles		P		S							S P			
Fluorescent Lamps		S		P					S		P			
Fluorescent Lamps		P		S							S P			
Metals				S P					S		P			
Metals		P		S							S P			
Lighting Fixtures				S P					S		P			
Lighting Fixtures		P		S							S P			
Concrete				S P					S		P			
Concrete		P		S							S P			
Glass				S P					S		P			
Glass		P		S							S P			
Slate Shingles				S P					S		P			
Construction Waste														
Paper products		S		P					S		P			
Paper products		P		S							S P			
Landscaping/Compostable Waste		S		P					S		P			
Metals		S		P					S		P			
Metals		P		S							S P			
Plastics		S P							S P					
Wood		S		P					S		P			
Wood		P		S							S P			
Sheetrock		S	P						S	P				
Sheetrock		P		S							S P			
Other		S P							S P					
Collected Wastewater														
Stormwater					P	S						P	S	
Sanitary Wastewater				S P							S P			
Other Contaminants		S P							P				S	
Sediment Runoff														
Topsoil					P	S			S	P				
Clay Sediment					P	S			S	P				
Other Contaminants					P	S			S	P				
Groundwater Infiltration														
Water					S	P							S	P
Sediment		S	P						S	P				
Other Contaminants		S	P						S	P				

Inputs - Operations & Maintenance		Unsustainable		Exactly Sustainable		Super-Sustainable			Unsustainable		Exactly Sustainable		Super-Sustainable	
Precipitation/Stormwater														
Water						S P							S P	
Solar Radiation														
Heat						S P							S P	
Light						S P							S P	
Electrical Power														
Electricity		S	P						S	P				
Potable Water														
Water		S	P						S	P				
Interior Finishes														
Paint - standard		S		P					S		P			
Paint - Low VOC		P		S							S P			
Carpet		S		P					S		P			
Recycled carpet tiles		P		S					P		S			
Tile				S P							S P			
Ceiling Systems				S P							S P			
Recycled ceiling panels				S P							S P			
Trim		S P							S P					
Replacement FF&E														
Movable Partitions		S	P						S	P				
Other Furniture		S	P						S	P				
Commodities														
Lamps		S	P						S	P				
Towels		S P							S P					
Hand Soap		S P							S P					
Toilet Paper		S P							S P					
Trash Can Liners		S P							S P					
Other				S P							S P			
Cleaning Products														
General Purpose		S P							S P					
Toilet Cleaners		S P							S P					
Floor Cleaners		S P							S P					
Carpet Cleaners		S P							S P					
Glass Cleaners		S P							S P					
Maintenance Products														
Lubricants		S P							S P					
Sealants/Caulks	P	S						P	S					
Refrigerants		S	P						S	P				
Pesticides/Fertilizers		S		P					S		P			
Asphalt Products		S	P						S	P				
User Products														
Paper Products		S P							S P					
Foods/Beverages		S P							S P					
General Office Supplies		S P							S P					
Toner/Printing Cartridges		S P							S P					
Other				S P							S P			

	Outputs - Operations & Maintenance		Unsustainable		Exactly Sustainable		Super-Sustainable			Unsustainable		Exactly Sustainable		Super-Sustainable	
Fugitive Emissions															
	Heat		S P							S P					
	Light		S	P						S	P				
	Particulates		S	P						S	P				
	Air Pollutants		S P							S P					
Solid Waste															
	Paper		P		S					P		S			
	Cardboard		P		S					P		S			
	Plastics		S P							S P					
	Wood		S P							S P					
	Food Waste		S P							S P					
	Glass		S P							S P					
	Metals		P		S					P		S			
	Landscaping/Compostable Waste		S P							S P					
	Hazardous Wastes		S P							S P					
	Other		S P							S P					
Collected Wastewater															
	Stormwater					P	S						P	S	
	Sanitary Wastewater					P	S						P	S	
	Other Contaminants					P	S						P	S	
Groundwater Infiltration															
	Water						S	P						S	P
	Sediment		S	P						S	P				
	Other Contaminants		S	P						S	P				

Appendix C: Impact Chain Analysis

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Impact Chains - Construction Inputs

Functional Requirements	Associated Subsystem	Flow	Source	Impacts
Protection from external climate	Building envelope	Windows	Unknown manufacturer	Manufacturing/transport impacts
Historical aesthetics		Doors	Unknown manufacturer	Manufacturing/transport impacts
provision of thermal comfort		Roof - recycled rubber	Unknown manufacturer	Manufacturing/transport impacts
Acoustic isolation/ privacy		Insulation - blown cellulose	Unknown manufacturer	Manufacturing/transport impacts
		Insulation - thermal acoustic panels	Unknown manufacturer	Manufacturing/transport impacts
Aesthetic appearance	Interior finishes	Paint - Low VOC	Unknown manufacturer	Manufacturing/transport impacts
Provision of maintainable surfaces		Carpet Tile	Unknown manufacturer	Manufacturing/transport impacts
Acoustic control/ privacy		Tile	Unknown manufacturer	Manufacturing/transport impacts
		Trim	Unknown manufacturer	Manufacturing/transport impacts
Provision of work surfaces	FF&E	Movable Partitions	Unknown manufacturer	Manufacturing/transport impacts
Delineation of space		Other Furniture	Unknown manufacturer	Manufacturing/transport impacts
Provision of storage		Recycled solid surface countertops	Unknown manufacturer	Manufacturing/transport impacts
Provision of thermal comfort	HVAC	HVAC Piping	Unknown manufacturer	Manufacturing/transport impacts
Provision of air quality		Ductwork	Unknown manufacturer	Manufacturing/transport impacts
		Geothermal system	Unknown manufacturer	Manufacturing/transport impacts
		Automated ventilation controls	Unknown manufacturer	Manufacturing/transport impacts
		IAQ sensors	Unknown manufacturer	Manufacturing/transport impacts
		VAV Air Handler	Unknown manufacturer	Manufacturing/transport impacts
Provision of electrical power to plugs	Electrical	Wiring	Unknown manufacturer	Manufacturing/transport impacts
Provision of electrical power to building equipment		Conduit	Unknown manufacturer	Manufacturing/transport impacts
Provision of adequate light		Fuel cell generation system	Unknown manufacturer	Manufacturing/transport impacts
Provision of transportation refueling		Photovoltaic panels	Unknown manufacturer	Manufacturing/transport impacts
		Occupancy sensors	Unknown manufacturer	Manufacturing/transport impacts
		Photocells for outdoor lighting	Unknown manufacturer	Manufacturing/transport impacts
		Lighting Fixtures	Unknown manufacturer	Manufacturing/transport impacts
		Outlet Fixtures	Unknown manufacturer	Manufacturing/transport impacts
		AFV Refueling station	Unknown manufacturer	Manufacturing/transport impacts

Impact Chains - Construction Inputs

Functional Requirements	Associated Subsystem	Flow	Source	Impacts
Provision of fresh drinking water	Plumbing	Water/Wastewater Piping	Unknown manufacturer	Manufacturing/transport impacts
Provision of heated water for cleaning/showers		Sinks	Unknown manufacturer	Manufacturing/transport impacts
Provision of water for waste conveyance		Toilets	Unknown manufacturer	Manufacturing/transport impacts
Provision of water for irrigation		Graywater piping and storage	Unknown manufacturer	Manufacturing/transport impacts
provision of water for fire suppression		Rainwater cistern	Unknown manufacturer	Manufacturing/transport impacts
		Rainwater catchment system	Unknown manufacturer	Manufacturing/transport impacts
		Outdoor micropool	Unknown manufacturer	Manufacturing/transport impacts
		Sprinkler Fixtures	Unknown manufacturer	Manufacturing/transport impacts
		Geothermal desuperheater	Unknown manufacturer	Manufacturing/transport impacts
Provision of erosion control	Landscaping	Standard sod	Unknown manufacturer	Manufacturing/transport impacts
Provision of aesthetic appearance		Shrubbery	Unknown manufacturer	Manufacturing/transport impacts
Control of outdoor temperatures		Trees	Unknown manufacturer	Manufacturing/transport impacts
Provision of exterior functional space		Furnishings	Unknown manufacturer	Manufacturing/transport impacts
Provision of parking		Flyash concrete	Unknown manufacturer	Manufacturing/transport impacts
Provision of emergency access		Porous concrete	Unknown manufacturer	Manufacturing/transport impacts
Provision of handicapped access		Grasspave pavement	Unknown manufacturer	Manufacturing/transport impacts
Control of moisture penetration		Rainwater apron	Unknown manufacturer	Manufacturing/transport impacts
Storage for equipment		Bicycle storage	Unknown manufacturer	Manufacturing/transport impacts
Provision of exterior shelter		Sheltered bus stop	Unknown manufacturer	Manufacturing/transport impacts
Provision of handicapped access	Conveyance	Elevator	Unknown manufacturer	Manufacturing/transport impacts

Impact Chains - Construction Outputs

Functional Requirements	Associated Subsystem	Flow	Sink	Impacts
None; unneeded by-product	Fugitive emissions	Heat	Ambient environment	Air pollution; urban heat islands
		Dust/Air Pollutants	Ambient environment	Air pollution; flora disturbance
Prevention of waste accumulation on site	Demolition waste	Wood	Chipped/recycled on post	Recovery/separation/transport impacts
		Bathroom Fixtures	Landfill/salvage	Recovery/separation/transport impacts
		Carpet	Recycler	Recovery/separation/transport impacts
		Ceiling Tiles	Recycler	Recovery/separation/transport impacts
		Fluorescent Lamps	Recycler	Recovery/separation/transport impacts
		Metals	Recycler	Recovery/separation/transport impacts
		Lighting Fixtures	Recycler	Recovery/separation/transport impacts
		Concrete	Recycler	Recovery/separation/transport impacts
		Glass	Recycler	Recovery/separation/transport impacts
Prevention of waste accumulation on site	Construction waste	Paper products	Recycler	Recovery/separation/transport impacts
		Metals	Recycler	Recovery/separation/transport impacts
		Plastics	Landfill	Transport/landfill storage impacts
		Wood	Chipped/recycled on post	Recovery/separation/transport impacts
		Sheetrock	Chipped/recycled on post	Recovery/separation/transport impacts
		Other	Landfill	Transport/landfill storage impacts
Prevention of waste accumulation on site	Wastewater system	Other Contaminants	City of Atlanta POTW	Sludge disposal/treatment impacts
Aesthetic appearance (unneeded by-products)	Landscape	Topsoil	Post sedimentation ponds	Degradation of water/soil quality
Prevention of waste accumulation on site		Clay Sediment	Post sedimentation ponds	Degradation of water/soil quality
		Other Contaminants	Post sedimentation ponds	Degradation of water/soil quality
		Sediment	Site landscape	Degradation of site ecosystems
		Other Contaminants	Site landscape	Degradation of site ecosystems

Impact Chains - Operations & Maintenance Inputs

Functional Requirements	Associated Subsystem	Flow	Source	Impacts
Provision of electrical power to plugs	All systems requiring electrical power	Electricity	Grid/fossil fuel-fired plant	Air pollution; depletion of nonrenewables
Provision of electrical power to building equipment				
Provision of adequate light				
provision of fresh drinking water	Potable water	Water	Chattahoochee/East Point	Water depletion; watershed disturbance
Provision of heated water for cleaning/showers				
Provision of water for waste conveyance				
Provision of water for irrigation				
Provision of water for fire suppression				
Aesthetic appearance	Interior finishes	Paint - Low VOC	Unknown manufacturer	Manufacturing/transport impacts
Provision of maintainable surfaces		Recycled carpet tiles	Unknown manufacturer	Manufacturing/transport impacts
Acoustic control		Trim	Unknown manufacturer	Manufacturing/transport impacts
Provision of work surfaces	FF&E	Movable Partitions	Unknown manufacturer	Manufacturing/transport impacts
Delineation of space		Other Furniture	Unknown manufacturer	Manufacturing/transport impacts
Provision of storage				
Provision of lighting	Commodities	Lamps	Unknown manufacturer	Manufacturing/transport impacts
Provision of hygeine		Towels	Unknown manufacturer	Manufacturing/transport impacts
Provision for removing waste from site		Hand Soap	Unknown manufacturer	Manufacturing/transport impacts
		Toilet Paper	Unknown manufacturer	Manufacturing/transport impacts
		Trash Can Liners	Unknown manufacturer	Manufacturing/transport impacts
Provision of clean spaces	Cleaning products	General Purpose	Unknown manufacturer	Manufacturing/transport impacts
Aesthetic appearance		Toilet Cleaners	Unknown manufacturer	Manufacturing/transport impacts
Sanitation		Floor Cleaners	Unknown manufacturer	Manufacturing/transport impacts
Enhanced visibility		Carpet Cleaners	Unknown manufacturer	Manufacturing/transport impacts
		Glass Cleaners	Unknown manufacturer	Manufacturing/transport impacts
Provision for the needs of other building systems	Maintenance products	Lubricants	Unknown manufacturer	Manufacturing/transport impacts
Provision of thermal comfort		Sealants/Caulks	Unknown manufacturer	Manufacturing/transport impacts
Provision of parking areas		Refrigerants	Unknown manufacturer	Manufacturing/transport impacts
		Asphalt Products	Unknown manufacturer	Manufacturing/transport impacts
Provision for basic office functions	User products	Paper Products	Unknown manufacturer	Manufacturing/transport impacts
Provision for basic human amenities		Foods/Beverages	Unknown manufacturer	Manufacturing/transport impacts
		General Office Supplies	Unknown manufacturer	Manufacturing/transport impacts
		Toner/Printing Cartridges	Unknown manufacturer	Manufacturing/transport impacts

Impact Chains - Operations & Maintenance Outputs

Functional Requirements	Associated Subsystem	Flow	Sink	Impacts
None; unneeded by-product	Fugitive emissions	Heat	Ambient environment	Air pollution; urban heat islands
		Light	Ambient environment	Ecosystem disturbance
		Particulates	Ambient environment	Air pollution; flora disturbance
		Air Pollutants	Ambient environment	Air pollution
prevention of waste accumulation on site	Solid waste	Paper	Post recycler	Recovery/separation/transport impacts
		Cardboard	Post recycler	Recovery/separation/transport impacts
		Plastics	Landfill	Transport/landfill storage impacts
		Wood	Landfill	Transport/landfill storage impacts
		Food Waste	Landfill	Transport/landfill storage impacts
		Glass	Landfill	Transport/landfill storage impacts
		Metals	Post recycler	Recovery/separation/transport impacts
		Landscaping/Compostable Waste	Landfill	Transport/landfill storage impacts
		Hazardous Wastes	Hazardous waste landfill	Transport/landfill storage impacts
		Other	Landfill	Transport/landfill storage impacts
Prevention of waste accumulation on site	Wastewater system	Sanitary Wastewater	City of Atlanta POTW	Sludge disposal/treatment impacts
Provision of sanitation		Other Contaminants	City of Atlanta POTW	Sludge disposal/treatment impacts
Prevention of waste accumulation on site	Groundwater infiltration	Sediment	Site landscape	Degradation of site ecosystems
Aesthetic appearance		Other Contaminants	Site landscape	Degradation of site ecosystems

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Appendix D: Best Available Technologies and Strategies

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Strategies for Impact Minimization – Construction Inputs

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Manufacturing/transport impacts of building envelope components	• Keep existing windows and doors in place; supplement as needed • Reduce user expectations for thermal comfort; require wear of appropriate clothing and do not modify building envelope	• Use completely recycled content envelope products (e.g., cellulose, steel for doors/window frames, roofing products) • Reuse products from other buildings (e.g., doors and interior windows) • Use sustainably harvested lumber for all wood products (doors and windows) • Use products generated close to site	▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods ▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)
Manufacturing/transport impacts of interior finishes	• Keep existing finishes in place; supplement as needed • Reduce user expectations for interior finishes and do not modify existing finishes	• Use only finishes that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components • Use products generated close to site	▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods ▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)
Manufacturing/transport impacts of FF&E	• Keep existing FF&E in place; supplement as needed • Reduce user expectations for FF&E and do not modify existing finishes • Reuse FF&E from occupants' present office space	• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components • Use products generated close to site	▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods ▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Manufacturing/transport impacts of HVAC system components	• Keep existing HVAC in place; supplement as needed • Reduce user expectations for HVAC and do not modify existing system	• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, recycled, or sustainably harvested components • Use products generated close to site	▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods ▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)
Manufacturing/transport impacts of electrical system components	• Keep existing electrical system components in place and supplement as needed • Reduce user requirements for power and do not modify existing system	• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, recycled, or sustainably harvested components • Use products generated close to site	▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods ▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)
Manufacturing/transport impacts of plumbing system components	• Keep existing plumbing system in place	• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, recycled, or sustainably harvested components • Use products generated close to site	▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods ▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Manufacturing/transport impacts of landscaping components	6.0 Keep all existing landscape and site features in place; do not modify	• Use only products that have been produced using completely sustainable growing processes, using only renewable, reused, recycled, or sustainably harvested components • Use products generated close to site	▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods ▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)
Manufacturing/transport impacts of conveyance components	• Repair existing elevator; do not replace • Keep second-floor breezeway to permit access to all building areas	• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, recycled, or sustainably harvested components • Use products generated close to site • Use elevator with high efficiency drive system	▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods ▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)

Strategies for Impact Minimization – Construction Outputs

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Air pollution, heat islands, and ecosystem disturbance from fugitive emissions	• Eliminate all fugitive emissions during construction using dust suppression/containment systems • Do not modify existing landscape, to reduce dust generation	• None	• Plant additional vegetation or restore local ecosystems to improve their ability to assimilate fugitive emissions	• Apply dust suppression systems at other projects to reduce corresponding amounts of fugitive emissions • Apply strategies at other locations to reduce urban heat island effects (e.g., high albedo roofing, preservation of landscape, ecosystem restoration)
Recovery/separation/transport impacts from demolition waste	• Avoid as much demolition as possible • Use manual separation to avoid impacts of associated equipment • Reuse as much material on site as possible (e.g., concrete/masonry rubble, cabinets as furnishings, etc.)	• Donate or give away all masonry units, furnishings, lighting fixtures, and wood for reuse	▪ Require all recyclers to reuse, then recycle, as much material as possible, using renewable energy and sustainable methods ▪ Require transport of all materials using sustainably-fueled vehicles or other sustainable mechanisms	• Recover corresponding amounts of materials from other projects and divert for reuse or recycling • Take action to avoid equivalent amounts of energy by other systems (energy offsets)

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Recovery/separation/transport impacts from construction waste	• Avoid as much construction as possible • Use manual separation to avoid impacts of associated equipment • Reuse as much material on site as possible (e.g., sheetrock as soil amendments, cardboard packaging for soil stabilization, etc.)	• Donate or give away all masonry units, furnishings, lighting fixtures, and wood for reuse	▪ Require all recyclers to reuse, then recycle, as much material as possible, using renewable energy and sustainable methods ▪ Require transport of all materials using sustainably-fueled vehicles or other sustainable mechanisms ▪ Require all product suppliers to take back all packaging, or minimize its use, or use reusable/recyclable/recycled packaging	• Recover corresponding amounts of materials from other projects and divert for reuse or recycling • Take action to avoid equivalent amounts of energy by other systems (energy offsets)
Sludge disposal/treatment impacts of wastewater	• Treat all wastewater on site using living machines or other technologies • Minimize use of water on site during construction	• Divert other wastewater streams besides stormwater to new wetlands-based treatment systems created by modifying post sed ponds	• Encourage City of Atlanta POTW to use land application of sludge instead of landfilling • Encourage Atlanta POTW to improve efficiency/sustainability of its treatment systems	• Prevent the generation of an equivalent amount of wastewater on other projects via the use of water-saving technologies

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Degradation of water/soil quality/site ecosystems from landscape modifications	• Do not modify existing landscape • Avoid the use of heavy equipment during construction to avoid landscape disturbance • Stage all equipment, storage, and dumpsters on paved (rather than vegetated) areas to avoid disturbance • Use sedimentation fencing, mulch, or other methods to immediately protect disturbed areas • Avoid the use of any product that could contaminate the site soil, landscape, or groundwater during construction. Divert all wastes to appropriate receptacles • Reduce user expectations for "instant landscaping" and plant more, less-developed plants rather than fewer well-developed ones	• Use only native plantings to avoid the need for chemical fertilizers, pesticides, or irrigation • Avoid the use of annual plants; use perennials in all applications	• Repair any damage done to site ecosystems using ecosystem restoration/decontamination methods	• Preserve an equivalent amount of landscape/ecosystem/vegetation on another project

Strategies for Impact Minimization – Operations & Maintenance Inputs

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Air pollution/nonrenewables depletion from electrical power generation requirements	• Eliminate the need for off-site electrical power by using on-site renewable generation (e.g., photovoltaics) for all electrical loads • Optimize building envelope, mechanical systems, lighting systems, and other power loads using best available technologies • Reduce user expectations for hot water and eliminate hot water heating system • Use on-demand hot water heaters to minimize energy wasted due to unnecessary hot water reserves • Use LED egress lighting to permanently light all corridors • Reduce user expectations for thermal control and downsize mechanical systems • Reduce user expectations for plug power • Replace all power-using equipment (e.g., computers, copiers, etc.) with high efficiency models that have standby modes • Turn off equipment not being used • Justify the need for all office	• Replace selected electric equipment with natural gas or biofuel equipment (e.g., hot water heaters, heating systems) • Require utility suppliers to provide green power generation from renewable sources	• Work with GA Power to convert existing plants to more sustainable or efficient options • Work with GA Power to ensure installation of best available technologies for emissions controls • Work with GA Power to promote energy conservation and load balancing efforts among their customer base, in order to increase the efficiency/sustainability of their overall generation system • Plant vegetation and restore ecosystems to improve the ability of the natural environment to assimilate air pollution	• Take action to avoid equivalent amounts of energy consumption by other systems (energy offsets), e.g., installing energy efficient lighting, HVAC, etc. in other buildings • Prevent an equivalent amount of air pollution by reducing emissions from other sources

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
	equipment			
Water depletion and watershed disturbance from potable water requirements	• Eliminate the need for water for waste conveyance by using only waterless urinals and composting/incinerating toilets • Eliminate the need for providing drinking water by requiring all users to provide their own water • Do not irrigate landscape • Minimize the need for water by using mechanical rather than chemical cleaning wherever possible	• Eliminate the need for water imports by installing enough storage to meet all needs using collected rainwater • Recycle wastewater on site to displace potable water imports, e.g., by using graywater for toilet flushing, and on-site treated water for all nonpotable uses	• Work with City of Atlanta/East Point to reduce distribution losses via leak repair • Work with City of Atlanta/East Point to promote water conservation	• Prevent the consumption of an equivalent amount of potable water by installing water-efficient appliances or repairing line leaks in other projects
Manufacturing/transport impacts from interior finishes	• Keep existing finishes in place; supplement as needed • Reduce user expectations for interior finishes and do not modify existing finishes	• Use only finishes that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components • Use products generated close to site	5) Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods 6) Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Manufacturing/transport impacts of FF&E	• Keep existing FF&E in place; supplement as needed • Reduce user expectations for FF&E and do not modify existing finishes	• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components • Use products generated close to site	7) Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods 8) Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the was te streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)
Manufacturing/transport impacts of commodities	• Use LED lighting or CFL lighting that last longer and require less frequent bulb replacement • Require users to provide their own towels for drying hands; do not supply disposable towels • Do not use trash can liners except in receptacles for food waste or compostable waste • Do not use liquid hand soap; use bar soap instead	• Use only toilet paper from recycled or sustainably harvested sources • Use only trash can liners made from recycled plastic or from corn starch or other renewable materials • Use only bio-based soaps that do not require use of nonrenewable resources • Use lamps made from recycled materials • Use products manufactured close to site	9) Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods 10) Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Manufacturing/transport impacts of cleaning products	• Avoid the use of specialized cleaners • Use mechanical rather than chemical cleaning wherever possible	• Use only water-based or bio-based cleaning products • Purchase in large containers and transfer as needed to small containers that are reused • Purchase products only from manufacturers that demonstrate sustainable manufacturing processes • Use products manufactured close to site	11) Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods 12) Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)
Manufacturing/transport impacts of maintenance products	• Maintain all equipment and finishes using appropriate practices to avoid the need for excess maintenance products • Regularly inspect all systems to avoid the need for significant repairs	• Use only water-based or bio-based lubricants and sealants when practical • Purchase in large containers and transfer as needed to small containers that are reused • Purchase products only from manufacturers that demonstrate sustainable manufacturing processes • Use products manufactured close to site	13) Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods 14) Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Manufacturing/transport impacts of user products	• Audit all office practices to minimize the need for general office supplies • Restrict users from printing/copying; require electronic distribution of documents • Require users to provide their own food service supplies (e.g., plates, cups, silverware, napkins, etc.)	• Use reusable plates, cups, silverware, and other food service supplies rather than disposable ones • Use GOOS (Good on one Side) paper for all draft documents and notes • Use products with maximal post-consumer recycled content or from sustainably harvested sources • Use alternatives to paper-based operations, including electronic presentations, electronic whiteboards, etc.	15) Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods 16) Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets) • Take action to avoid equivalent amounts of energy by other systems (energy offsets)

Strategies for Impact Minimization – Operations & Maintenance Outputs

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Air pollution, heat islands, and ecosystem disturbance from fugitive emissions	• Eliminate all fugitive emissions by avoiding landscape disturbance • Minimize or eliminate external site lighting	• None	• Plant additional vegetation or restore local ecosystems to improve their ability to assimilate fugitive emissions	• Apply strategies at other locations to reduce urban heat island effects (e.g., high albedo roofing, preservation of landscape, ecosystem restoration)
Recovery/separation/transport/landfill storage impacts from solid waste	• Audit all office practices to minimize the need for general office supplies (and subsequent waste generation) • Restrict users from printing/copying; require electronic distribution of documents • Use manual separation to avoid impacts of associated equipment • Reuse as much material on site as possible (e.g., GOOS paper, disposable silverware, etc.) • Require users to empty their own waste receptacles	• Donate or give away any waste products that could be reused • Use only products that come with no or minimal packaging • Use only products whose packaging can be composted on site • Use durable rather than disposable products • Use GOOS (Good on one Side) paper for all draft documents and notes • Use products with maximal post-consumer recycled content or from sustainably harvested sources • Use alternatives to paper-based operations, including electronic presentations, electronic whiteboards, etc.	▪ Require all recyclers to reuse, then recycle, as much material as possible, using renewable energy and sustainable methods ▪ Require transport of all materials using sustainably-fueled vehicles or other sustainable mechanisms	• Recover corresponding amounts of materials from other projects and divert for reuse or recycling • Take action to avoid equivalent amounts of energy by other systems (energy offsets)

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
Sludge disposal/treatment impacts from wastewater	• Treat all wastewater on site using living machines or other technologies • Minimize generation of wastewater by using waterless or ultra-conserving fixtures such as waterless urinals or composting/incinerating toilets	• Divert other wastewater streams besides stormwater to new wetlands-based treatment systems created by modifying post sed ponds	• Encourage City of Atlanta POTW to use land application of sludge instead of landfilling • Encourage Atlanta POTW to improve efficiency/sustainability of its treatment systems	• Prevent the generation of an equivalent amount of wastewater on other projects via the use of water-saving technologies
Degradation of site ecosystems from contaminant infiltration into landscape	• Do not modify existing landscape • Avoid the use of heavy equipment during operations/maintenance to avoid landscape disturbance • Stage all equipment, storage, and dumpsters on paved (rather than vegetated) areas to avoid disturbance • Use sedimentation fencing, mulch, or other methods to immediately protect disturbed areas • Avoid the use of any product that could contaminate the site soil, landscape, or groundwater during operations/maintenance. Divert all wastes to appropriate receptacles • Use manual methods wherever possible for landscape maintenance	• Use only organic products for landscape maintenance • Use integrated pest management • Use only native plantings to avoid the need for chemical fertilizers, pesticides, or irrigation • Avoid the use of annual plants; use perennials in all applications	• Repair any damage done to site ecosystems using ecosystem restoration/decontamination methods	• Preserve an equivalent amount of landscape/ecosystem/vegetation on another project

Impact	First-order Strategies	Second-order Strategies	Third-order Strategies	Fourth-order Strategies
	(e.g., rakes instead of leaf blowers)			

Appendix E: BATS Ratings – Risk and Reliability

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BATS for Minimizing Impacts of Construction Inputs

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
Manufacturing/transport impacts of building envelope components				
• Keep existing windows and doors in place; supplement as needed	A	A	B	A
• Reduce user expectations for thermal comfort; require wear of appropriate clothing and do not modify building envelope	A	D	A	C
• Use completely recycled content envelope products (e.g., cellulose, steel for doors/window frames, roofing products)	B	A	C	D
• Reuse products from other buildings (e.g., doors and interior windows)	B	B	B	B
• Use sustainably harvested lumber for all wood products (doors and windows)	B	A	B	C
• Use products generated close to site	B	A	B	B
• Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	C
• Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of interior finishes				
• Keep existing finishes in place; supplement as needed	A	A	B	A
• Reduce user expectations for interior finishes and do not modify existing finishes	A	D	A	C
• Use only finishes that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components	B	A	B	B

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
• Use products generated close to site	B	A	B	B
• Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	C
• Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of FF&E				
• Keep existing FF&E in place; supplement as needed	A	A	B	A
• Reduce user expectations for FF&E and do not modify existing finishes	A	D	A	C
• Reuse FF&E from occupants' present office space	A	A	A	A
• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components	B	A	B	B
• Use products generated close to site	B	A	B	B
• Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	C
• Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of HVAC system components				

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
• Keep existing HVAC in place; supplement as needed	A	A	B	B
• Reduce user expectations for HVAC and do not modify existing system	A	D	A	C
• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, recycled, or sustainably harvested components	B	A	B	D
• Use products generated close to site	B	A	B	B
• Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	D
• Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of electrical system components				
• Keep existing electrical system components in place and supplement as needed	A	A	B	B
• Reduce user requirements for power and do not modify existing system	A	D	A	C
• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, recycled, or sustainably harvested components	B	A	B	D
• Use products generated close to site	B	A	B	B
• Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	D
• Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of plumbing system components				
• Keep existing plumbing system in place	A	A	A	A
• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, recycled, or sustainably harvested components	B	A	B	B
• Use products generated close to site	B	A	B	B
• Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	C
• Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	C
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of landscaping components				
• Keep all existing landscape and site features in place; do not modify	A	A	A	A
• Use only products that have been produced using completely sustainable growing processes, using only renewable, reused, recycled, or sustainably harvested components	B	A	B	B
• Use products generated close to site	B	A	B	C
• Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	B

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
• Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of conveyance components				
• Repair existing elevator; do not replace	A	A	A	B
• Keep second-floor breezeway to permit access to all building areas	A	A	A	A
• Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, recycled, or sustainably harvested components	B	A	B	D
• Use products generated close to site	B	A	B	D
• Use elevator with high efficiency drive system	B	A	B	B
• Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	D
• Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	B
• Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B

BATS for Minimizing Impacts of Construction Outputs

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
Air pollution, heat islands, and ecosystem disturbance from fugitive emissions				
• Eliminate all fugitive emissions during construction using dust suppression/containment systems	A	B	C	C
• Do not modify existing landscape, to reduce dust generation	A	A	A	B
• Plant additional vegetation or restore local ecosystems to improve their ability to assimilate fugitive emissions	C	B	C	B
• Apply dust suppression systems at other projects to reduce corresponding amounts of fugitive emissions	D	B	D	C
• Apply strategies at other locations to reduce urban heat island effects (e.g., high albedo roofing, preservation of landscape, ecosystem restoration)	D	B	D	C
Recovery/separation/transport impacts from demolition waste				
• Avoid as much demolition as possible	A	B	B	B
• Use manual separation to avoid impacts of associated equipment	A	B	B	B
• Reuse as much material on site as possible (e.g., concrete/masonry rubble, cabinets as furnishings, etc.)	A	B	B	B
• Donate or give away all masonry units, furnishings, lighting fixtures, and wood for reuse	B	A	B	B
• Require all recyclers to reuse, then recycle, as much material as possible, using renewable energy and sustainable methods	C	A	B	C
• Require transport of all materials using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
• Recover corresponding amounts of materials from other projects and divert for reuse or recycling	D	B	A	B

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Recovery/separation/transport impacts from construction waste				
• Avoid as much construction as possible	A	B	B	B
• Use manual separation to avoid impacts of associated equipment	A	B	B	B
• Reuse as much material on site as possible (e.g., sheetrock as soil amendments, cardboard packaging for soil stabilization, etc.)	A	B	B	B
• Donate or give away all masonry units, furnishings, lighting fixtures, and wood for reuse	B	A	B	B
• Require all recyclers to reuse, then recycle, as much material as possible, using renewable energy and sustainable methods	C	A	B	C
• Require transport of all materials using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
• Require all product suppliers to take back all packaging, or minimize its use, or use reusable/recyclable/recycled packaging	C	A	B	C
• Recover corresponding amounts of materials from other projects and divert for reuse or recycling	D	B	A	B
• Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Sludge disposal/treatment impacts of wastewater				
• Treat all wastewater on site using living machines or other technologies	A	B	A	C
• Minimize use of water on site during construction	A	B	B	B
• Divert other wastewater streams besides stormwater to new wetlands -based treatment systems created by modifying post sed ponds	B	B	A	B
• Encourage City of Atlanta POTW to use land application of sludge instead of landfilling	C	A	D	C

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
• Encourage Atlanta POTW to improve efficiency/sustainability of its treatment systems	C	A	B	C
• Prevent the generation of an equivalent amount of wastewater on other projects via the use of water-saving technologies	D	B	A	B
Degradation of water/soil quality/site ecosystems from landscape modifications				
• Do not modify existing landscape	A	B	A	B
• Avoid the use of heavy equipment during construction to avoid landscape disturbance	A	B	A	B
• Stage all equipment, storage, and dumpsters on paved (rather than vegetated) areas to avoid disturbance	A	B	A	B
• Use sedimentation fencing, mulch, or other methods to immediately protect disturbed areas	A	B	B	B
• Avoid the use of any product that could contaminate the site soil, landscape, or groundwater during construction. Divert all wastes to appropriate receptacles	A	B	B	C
• Reduce user expectations for "instant landscaping" and plant more, less-developed plants rather than fewer well-developed ones	A	C	B	B
• Use only native plantings to avoid the need for chemical fertilizers, pesticides, or irrigation	B	C	B	B
• Avoid the use of annual plants; use perennials in all applications	B	C	B	B
• Repair any damage done to site ecosystems using ecosystem restoration/decontamination methods	C	B	C	B
• Preserve an equivalent amount of landscape/ecosystem/vegetation on another project	D	B	A	B

BATS for Minimizing Impacts of Operations & Maintenance Inputs

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
Air pollution/nonrenewables depletion from electrical power generation requirements				
▪ Eliminate the need for off-site electrical power by using on-site renewable generation (e.g., photovoltaics) for all electrical loads	A	B	C	C
▪ Optimize building envelope, mechanical systems, lighting systems, and other power loads using best available technologies	A	B	D	C
▪ Reduce user expectations for hot water and eliminate hot water heating system	A	D	B	C
▪ Use on-demand hot water heaters to minimize energy wasted due to unnecessary hot water reserves	A	C	D	B
▪ Use LED egress lighting to permanently light all corridors	A	C	D	B
▪ Reduce user expectations for thermal control and downsize mechanical systems	A	C	B	B
▪ Reduce user expectations for plug power	A	D	B	C
▪ Replace all power-using equipment (e.g., computers, copiers, etc.) with high efficiency models that have standby modes	A	A	D	C
▪ Turn off equipment not being used	A	D	B	B
▪ Justify the need for all office equipment	A	B	B	B
▪ Replace selected electric equipment with natural gas or biofuel equipment (e.g., hot water heaters, heating systems)	B	B	D	C
▪ Require utility suppliers to provide green power generation from renewable sources	B	A	B	D
▪ Work with GA Power to convert existing plants to more sustainable or efficient options	C	B	D	C
▪ Work with GA Power to ensure installation of best available technologies for emissions controls	C	B	D	C

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
▪ Work with GA Power to promote energy conservation and load balancing efforts among their customer base, in order to increase the efficiency/sustainability of their overall generation system	C	B	B	C
▪ Plant vegetation and restore ecosystems to improve the ability of the natural environment to assimilate air pollution	C	B	B	B
▪ Take action to avoid equivalent amounts of energy consumption by other systems (energy offsets), e.g., installing energy efficient lighting, HVAC, etc. in other buildings	D	B	C	B
▪ Prevent an equivalent amount of air pollution by reducing emissions from other sources	D	B	B	B
Water depletion and watershed disturbance from potable water requirements				
▪ Eliminate the need for water for waste conveyance by using only waterless urinals and composting/incinerating toilets	A	C	C	C
▪ Eliminate the need for providing drinking water by requiring all users to provide their own water	A	D	B	B
▪ Do not irrigate landscape	A	C	B	B
▪ Minimize the need for water by using mechanical rather than chemical cleaning wherever possible	A	B	B	C
▪ Eliminate the need for water imports by installing enough storage to meet all needs using collected rainwater	B	A	C	C
▪ Recycle wastewater on site to displace potable water imports, e.g., by using graywater for toilet flushing, and on-site treated water for all nonpotable uses	B	B	D	C
▪ Work with City of Atlanta/East Point to reduce distribution losses via leak repair	C	B	B	C
▪ Work with City of Atlanta/East Point to promote water conservation	C	B	B	B
▪ Prevent the consumption of an equivalent amount of potable water by installing water-efficient appliances or repairing line leaks in other projects	D	B	C	B

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
Manufacturing/transport impacts from interior finishes				
▪ Keep existing finishes in place; supplement as needed	A	A	B	A
▪ Reduce user expectations for interior finishes and do not modify existing finishes	A	D	A	C
▪ Use only finishes that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components	B	A	B	B
▪ Use products generated close to site	B	A	B	B
▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	C
▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
▪ Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
▪ Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of FF&E				
▪ Keep existing FF&E in place; supplement as needed	A	A	B	A
▪ Reduce user expectations for FF&E and do not modify existing finishes	A	D	A	C
▪ Use only products that have been produced using completely sustainable manufacturing processes, from renewable, reused, or sustainably harvested components	B	A	B	B
▪ Use products generated close to site	B	A	B	B
▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	C

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
▪ Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
▪ Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of commodities				
▪ Use LED lighting or CFL lighting that last longer and require less frequent bulb replacement	A	B	C	B
▪ Require users to provide their own towels for drying hands; do not supply disposable towels	A	D	A	C
▪ Do not use trash can liners except in receptacles for food waste or compostable waste	A	B	B	B
▪ Do not use liquid hand soap; use bar soap instead	A	C	B	B
▪ Use only toilet paper from recycled or sustainably harvested sources	B	A	B	B
▪ Use only trash can liners made from recycled plastic or from corn starch or other renewable materials	B	A	B	B
▪ Use only bio-based soaps that do not require use of nonrenewable resources	B	A	B	B
▪ Use lamps made from recycled materials	B	A	B	B
▪ Use products manufactured close to site	B	A	B	B
▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	B
▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
▪ Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
▪ Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of cleaning products				
▪ Avoid the use of specialized cleaners	A	B	B	B
▪ Use mechanical rather than chemical cleaning wherever possible	A	B	B	C
▪ Use only water-based or bio-based cleaning products	B	B	B	B
▪ Purchase in large containers and transfer as needed to small containers that are reused	B	B	B	B
▪ Purchase products only from manufacturers that demonstrate sustainable manufacturing processes	B	A	B	B
▪ Use products manufactured close to site	B	A	B	C
▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	C
▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
▪ Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
▪ Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of maintenance products				
▪ Maintain all equipment and finishes using appropriate practices to avoid the need for excess maintenance products	A	B	B	B
▪ Regularly inspect all systems to avoid the need for significant repairs	A	B	B	B
▪ Use only water-based or bio-based lubricants and sealants when practical	B	B	B	C

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
▪ Purchase in large containers and transfer as needed to small containers that are reused	B	B	B	B
▪ Purchase products only from manufacturers that demonstrate sustainable manufacturing processes	B	A	B	B
▪ Use products manufactured close to site	B	A	B	C
▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	C
▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
▪ Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
▪ Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Manufacturing/transport impacts of user products				
▪ Audit all office practices to minimize the need for general office supplies	A	C	B	A
▪ Restrict users from printing/copying; require electronic distribution of documents	A	D	B	B
▪ Require users to provide their own food service supplies (e.g., plates, cups, silverware, napkins, etc.)	A	D	B	B
▪ Use reusable plates, cups, silverware, and other food service supplies rather than disposable ones	B	C	D	B
▪ Use GOOS (Good on one Side) paper for all draft documents and notes	B	D	B	B
▪ Use products with maximal post-consumer recycled content or from sustainably harvested sources	B	A	B	B
▪ Use alternatives to paper-based operations, including electronic presentations, electronic whiteboards, etc.	B	C	D	C

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
▪ Require all product providers to use completely recycled , reused, or sustainably harvested products, generated using renewable energy and sustainable production methods	C	A	B	C
▪ Require transport of all products using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
▪ Remove equivalent amounts of materials from the waste streams of other systems (materials offsets)	D	B	A	B
▪ Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B

BATS for Minimizing Impacts of Operations & Maintenance Outputs

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
Air pollution, heat islands, and ecosystem disturbance from fugitive emissions				
▪ Eliminate all fugitive emissions by avoiding landscape disturbance	A	B	B	A
▪ Minimize or eliminate external site lighting	A	C	B	C
▪ Plant additional vegetation or restore local ecosystems to improve their ability to assimilate fugitive emissions	C	B	B	B
▪ Apply strategies at other locations to reduce urban heat island effects (e.g., high albedo roofing, preservation of landscape, ecosystem restoration)	D	B	D	C
Recovery/separation/transport/landfill storage impacts from solid waste				
▪ Audit all office practices to minimize the need for general office supplies (and subsequent waste generation)	A	C	B	A
▪ Restrict users from printing/copying; require electronic distribution of documents	A	D	B	B
▪ Use manual separation to avoid impacts of associated equipment	A	D	B	B
▪ Reuse as much material on site as possible (e.g., GOOS paper, disposable silverware, etc.)	A	D	B	B
▪ Require users to empty their own waste receptacles	A	D	B	C
▪ Donate or give away any waste products that could be reused	B	B	B	B
▪ Use only products that come with no or minimal packaging	B	C	B	C
▪ Use only products whose packaging can be composted on site	B	B	B	B
▪ Use durable rather than disposable products	B	C	D	B
▪ Use GOOS (Good on one Side) paper for all draft documents and notes	B	D	B	B
▪ Use products with maximal post-consumer recycled content or from sustainably harvested sources	B	A	B	B

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
▪ Use alternatives to paper-based operations, including electronic presentations, electronic whiteboards, etc.	B	C	D	C
▪ Require all recyclers to reuse, then recycle, as much material as possible, using renewable energy and sustainable methods	C	A	B	C
▪ Require transport of all materials using sustainably-fueled vehicles or other sustainable mechanisms	C	A	B	C
▪ Recover corresponding amounts of materials from other projects and divert for reuse or recycling	D	B	A	B
▪ Take action to avoid equivalent amounts of energy by other systems (energy offsets)	D	B	A	B
Sludge disposal/treatment impacts from wastewater				
▪ Treat all wastewater on site using living machines or other technologies	A	C	A	C
▪ Minimize generation of wastewater by using waterless or ultra-conserving fixtures such as waterless urinals or composting/incinerating toilets	A	C	D	C
▪ Divert other wastewater streams besides stormwater to new wetlands-based treatment systems created by modifying post sed ponds	B	B	A	B
▪ Encourage City of Atlanta POTW to use land application of sludge instead of landfilling	C	A	D	C
▪ Encourage Atlanta POTW to improve efficiency/sustainability of its treatment systems	C	A	B	C
▪ Prevent the generation of an equivalent amount of wastewater on other projects via the use of water-saving technologies	D	B	A	B
Degradation of site ecosystems from contaminant infiltration into landscape				
▪ Do not modify existing landscape	A	B	A	A
▪ Avoid the use of heavy equipment during operations/maintenance to avoid landscape disturbance	A	B	A	B

STRATEGY	RISK	RELIABILITY	VALUE	DIFFICULTY
▪ Stage all equipment, storage, and dumpsters on paved (rather than vegetated) areas to avoid disturbance	A	B	A	A
▪ Use sedimentation fencing, mulch, or other methods to immediately protect disturbed areas	A	B	B	B
▪ Avoid the use of any product that could contaminate the site soil, landscape, or groundwater during operations/maintenance. Divert all wastes to appropriate receptacles	A	B	B	B
▪ Use manual m ethods wherever possible for landscape maintenance (e.g., rakes instead of leaf blowers)	A	B	B	C
▪ Use only organic products for landscape maintenance	B	B	B	B
▪ Use integrated pest management	B	B	B	C
▪ Use only native plantings to avoid the need for chemical fertilizers, pesticides, or irrigation	B	C	B	B
▪ Avoid the use of annual plants; use perennials in all applications	B	C	B	B
▪ Repair any damage done to site ecosystems using ecosystem restoration/decontamination methods	C	B	C	B
▪ Preserve an equivalent amount of landscape/ecosystem/vegetation on another project	D	B	A	B